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Public Health Service • Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service
Bureau of Radiological Health

Technical Notes

Zirconium-95 in Utah Vegetation Produced During the 1966 Growing Season[1]

R. C. Pendleton and *R. D. Lloyd*[2]

An unexpectedly intense gamma-ray peak at about 0.76 MeV was observed in a number of vegetation samples collected throughout Utah during 1966. These samples had been counted in February 1967 for the determination of cesium-137 levels. The spectrometer used consisted of a 400-channel pulse-height analyzer receiving signals from a pair of 8-by 4-inch NaI (Tl) crystals housed in a 6-inch thick steel shield and operating in concert (*1*). Counting data were analyzed by using computer techniques (*2*). All samples had been stored in double plastic bags since collection and the outer bag was removed just before the sample was counted. A few samples were repackaged in new containers and were recounted. No diminution of their 0.76 MeV peaks was produced by this procedure. In many samples, the peak at about 0.76 MeV dominated the gamma-ray spectra (figures 1 and 2). Some of the samples had been collected more than 8 months prior to counting, nearly four half-lives of zirconium-95, which was suspected as being responsible for the peak. Since no highly contaminating nuclear event was known to have occurred locally in 1966 and no announced ventings occurred in our area after April 1966, it seemed unlikely that a large amount of 65-day half-life zirconium-95 would have been present in significant amounts.

Four representative samples were selected for serial counting in an attempt to determine the

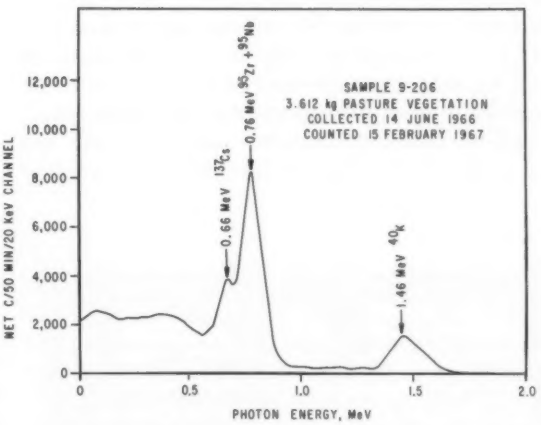

Figure 1. Photon spectrum of a typical vegetation

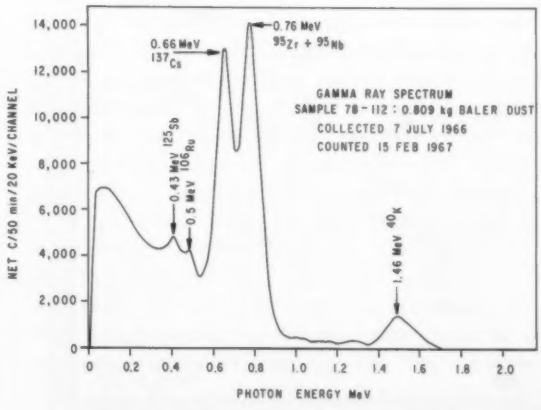

Figure 2. Photon spectrum of a baler dust sample

[1] This investigation was supported by U.S. Public Health Service Research Grant RH-00030, Bureau of Radiological Health.

[2] University of Utah, Salt Lake City, Utah.

radioactive half-life of the unknown emitter. Serial counting of these samples from February to October 1967 yielded an average half-life of 68.4 ± 6.2 days in agreement with the 65-day value for zirconium-95, but very different from the tabulated half-lives of other suspect radionuclides exhibiting gamma-ray energies of about 0.76 MeV (*3*).

No evidence of zirconium-95 was found in environmental samples collected in 1965. Only very small amounts of the nuclide (80 to 660 pCi/kg) were found in samples collected in the fallout tract of the "Pinstripe" event in southern Utah during April 1966. Inspection of collection dates for the 1966 vegetation samples suggested that the contaminating event probably occurred between May 14 and June 13, 1966, since samples collected May 14 at station number 60 showed no detectable zirconium-95, but samples collected at the same location on June 29 averaged about 14 nCi/kg, and those obtained at other locations on June 13 or later also contained this radionuclide. Much of this contaminated vegetation had not yet grown at the time of the "Pinstripe" venting and was collected far from the area of the fallout track. Maps of the location of origin for each contaminated sample showed that zirconium-95 had been widespread throughout the State of Utah (figure 3).

Table 1 lists the announced nuclear detonations during May and June 1966 (*4-5*). The Chinese device was detonated in the atmosphere and the United States tests were all underground. None of these underground explosions were reported to have vented.

Table 1. Announced nuclear detonations in May and June 1966

Date	Location	Yield (kilotons)
May 4	Nevada Test Site	<20
May 5	Nevada Test Site	<20
May 6	Nevada Test Site	20–200
May 9	China	200–1,000
May 12	Nevada Test Site	<20
May 13	Nevada Test Site	20–200
May 19	Nevada Test Site	20–200
May 27	Nevada Test Site	<20
June 2	Nevada Test Site	20–200
June 3	Nevada Test Site	20–200
June 10	Nevada Test Site	<20
June 25	Nevada Test Site	<20
June 30	Nevada Test Site	200–1,000

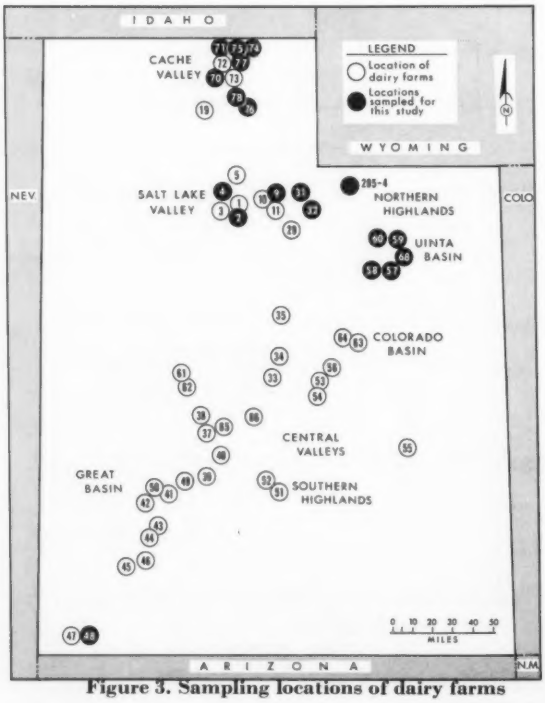

Figure 3. Sampling locations of dairy farms

Measurements made by the Utah State Department of Health (*6*) of gross beta radioactivity in air for Utah sampling stations for May and June 1966 did not reveal elevated air concentrations of radioactivity during the period May 14 to June 13 (table 2)[3]. Data from 19 sampling stations showed that radioactivity was detected in Utah air during the period, May 14 to June 13, but this was also true of March and early April when, presumably, no contaminating events occurred. For only 6 of the 19 Utah stations was the May maximum the highest of this 4-month period, and for 3 of the stations the May maximum was the lowest. Only a single station (Moab) exhibited a maximum which was significantly higher than the monthly average in mid-May when fallout from the third Chinese test was reported to have reached the Intermountain area. (*7*). Nine stations showed a maximum during the final 9 days of the month, but only 2 of these values (Parowan, Monticello) were much higher than typical maxima for the State during March. The exact date of

[3] Data in table 2 illustrate the clear-cut way in which the relatively small amount of fallout from the "Pinstripe" event was detected by this sampling network during the last week in April 1966. Utah stations in the fallout track were Cedar, Garrison, Monticello, Price, Provo, and Richfield. However, entry of the much more intense fallout from the May 9 Chinese test can not be similarly seen in the data for May.

Table 2. Dates and concentration of maximum measured gross beta radioactivity in the air at 19 Utah locations during March–June 1966

Station	March		April		May		June	
	Date of maximum	Maximum (pCi/m³)	Date of maximum	Maximum (pCi/m³)	Date of maximum	Maximum (pCi/m³)	Date of maximum	Maximum (pCi/m³)
Bryce (PHS)[b]	15	2.6	6, 23	2.6	15	1.5	30	3.3
Cedar (PHS)	26	2.0	26	2.4	29	3.4	4	3.5
Delta (PHS)	24	3.3	6	4.9	1	2.7	16	1.7
Dugway (PHS)	24	3.9	1	1.2	22	1.2	—	0
Garrison (PHS)	—	—	26	7.8	3	9.3	18	9.5
Logan	25	2.1	6	2.1	4, 9, 15, 31	2.1	27, 29, 30	2.1
Logan (PHS)	31	3.4	7	4.7	4	3.6	30	4.4
Moab	6	2.9	9	2.9	15	13.8	10	3.0
Monticello (PHS)	6	2.4	26	3.9	21	8.5	14, 18	2.9
Ogden	24	1.0	5, 14, 25	1.3	22	1.6	15, 20, 26	1.0
Parowan (PHS)	—	0	—	0	26	6.4	8	1.0
Price	12, 15, 24, 25	0.9	26	1.2	3, 12, 21	1.0	7	1.4
Provo (PHS)	31	2.8	26	10.3	2	2.7	1, 2	0.9
Richfield	26	3.2	26	16.2	25	2.6	11	2.2
Roosevelt (PHS)	24	8.7	6	6.7	9	4.9	29	4.9
Salt Lake (PHS)	6, 24, 25, 31	1.7	8	2.7	22	2.8	26	2.9
Salt Lake (RSN)[c]	10	2.7	9	1.8	22	6.2	1	1.7
St. George	17, 25	1.8	29	1.4	31	1.8	5, 6	1.4
Wendover (PHS)	25	3.6	14, 16, 21	3.2	14	3.1	23	7.5

[a] Source of data: Utah State Department of Health Document SDH–San–109–10/66, October 1966 (field estimates).
[b] Stations marked "PHS" were operated cooperatively with the U.S. Public Health Service.
[c] PHS Radiation Surveillance Network station.

this contaminating event cannot be deduced from these data. Therefore, the concentration of zirconium-95 in each vegetation sample was corrected for radioactive decay to June 1, 1966, for purposes of comparison (table 3 and figure 3).

Data supplied by the Southwestern Radiological Health Laboratory (SWRHL)[4] indicate that calculations of air beta-concentrations, based on their evaluation of these same filters at varying times after removal from the air samplers, are in serious disagreement with values reported in reference 6. Their estimates of air beta concentrations are higher in some cases and lower in others. In general the SWRHL data suggest a very long-term but chorologically varying exposure of the Utah air sampling network to freshly-produced fallout from mid-May to mid-June 1966. This is in agreement with the expectation that the May 9 test on the Chinese mainland was responsible for at least part of the radioactivity detected.

Several vegetation samples had been collected in southern Utah on April 30, 1966, following the April 25, 1966, venting of an underground nuclear detonation at the Nevada Test Site (*9*). Small quantities of the short-lived fission products, iodine-131, ruthenium-103, and zirconium-95, were detected in these 5 samples when counted on May 3, 1966. Dairy cattle in Utah were generally not grazing on open pastures at the time of the April 25, 1966 venting. The absence of significant amounts of iodine-131 in milk was confirmed by gamma-ray analysis of milk from several Salt Lake dairies and milk farms which showed iodine-131 in vegetation samples, However, cattle were on pasture by June, and the deposition of fresh fission products on vegetation during this time should have indicated by sharply rising iodine-131 levels in milk. The U.S. Public Health Service Pasturized Milk Network data for May and June 1966 showed only tiny increases in Utah milk (to 20 pCi/liter only and not until June 7 and 17) (*9-10*). Although the concentration of zirconium-95 in 1966 forage vegetation (table 3) was similar to that in samples collected following the Nevada tests of July 1962, iodine-131 milk levels were much higher in 1962 (up to 62,500 pCi/liter for milk contributed

[4] Melvin W. Carter, Southwestern Radiological Health Laboratory, personal communication.

to the Salt Lake milk pool) (see equation 3 and table 1, farm #60, in reference 12). During the 1962 incident, vegetation and milk were collected from a number of Utah dairy farms (*11*, figure 3). In two cases, vegetation and milk had been obtained from a farm at about the same time. For one, the vegetation contained about 24,000 pCi/kg of zirconium-95 and the milk had about 5,000 pCi/liter of iodine-131; for the other, the vegetation contained about 17,000 pCi/kg zirconium-95 and the milk had about 3,000 pCi/liter of iodine-131. The average ratio of iodine (pCi/liter of milk) to zirconium (pCi/kg of vegetation) in these 2 cases was about 0.2. Under similar conditions, 1966 milk may have had up to 7,120 pCi/liter of iodine-131 (table 3, farm #78). The 1962 "Sedan" event was a cratering shot, followed by "Small Boy" which was detonated at the earth's surface. It is conceivable that the fallout from a partially contained cratering event might have been enriched in the iodine isotopes relative to zirconium-95. Even if the difference in type of shot, particle size and delay of fallout arrival reduced the iodine-131 to zirconium-95 ratio by a factor of 9 to 36, milk obtained in 1966 might have been expected to have contained 200 to 800 pCi of iodine-131 per liter. Carter[4] estimated the reduction in the iodine-131 to zirconium-95 ratio in the fallout from the Chinese test conducted on May 9 compared with Sedan-Small Boy as a factor of 6 to 24 or more.

Levels of radioactive materials in the baler dust (figure 2, table 3) may be of possible significance because, in addition to the initial exposure of farm workers who may be in the open when a fallout cloud passes through, the farmer is exposed to subsequent secondary aerosols generated during harvesting or processing of crops which can have a relatively high concentration of radioactivity. Some samples of baler dust taken in 1966 contained near microcurie quantities of gamma-ray emitting nuclides per kg[5].

[5] For example, as of the date of collection, sample 4–206 contained per kg about 3,500 pCi antimony–125, 2,300 pCi ruthenium–106, 4,200 pCi cesium–137 and 190,000 pCi zirconium–95 plus about 410,000 pCi niobium–95. The total of these longer-lived, high-energy gamma-ray emitters is about 0.6 μCi. There was undoubtedly present, soon after deposition, many short-lived nuclides such as the iodine isotopes, ruthenium–103, barium–140, etc. The beta emitters; tritium, strontium–89, strontium–90, etc., were probably present but were not measured. In addition there may have also been quantities of plutonium–239 and other alpha-particle emitters.

Summary

Levels of zirconium-95 in crops and dust from farm implements indicated widespread contamination of Utah with fresh fission products during May or June 1966. Although the exact origin and date of arrival of the zirconium-95 in these vegetation samples cannot be determined from available evidence, at least part was probably from the atmospheric nuclear detonation on the Chinese mainland. No important increase of iodine-131, cesium-137, or strontium-90 has been reported for these months, but there is evidence that farm workers could have been exposed to secondary aerosols containing relatively high levels of radioactivity. This indicates that a potential radiological hazard may have occurred in past highly contaminating incidents and may recur, if a highly contaminating incident takes place in the future.

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(*9*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, May 1966 (table 1). Radiol Health Data Rep 7:494–497 (September 1966).

(*10*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, June 1966. (table 1). Radiol Health Data Rep 7:562–564 (October 1966).

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Table 3. Zirconium-95 in 1966 Utah vegetation collected after May 13

Station	Sample	Collection date (1966)	Sample type	Zirconium-95 (nCi/kg net weight) (corrected to 6/1/66)
2	203	6/13	pasture vegetation	9.7
	204		alfalfa	28.8
	205		baler dust[a]	105.3
	215	7/30	alfalfa	1.6
	216		pasture vegetation	2.7
	225	9/14	alfalfa	1.3
	226		grass hay	8.4
	229	9/18	pasture vegetation	1.2
4	204	6/13	pasture vegetation	5.1
	205		alfalfa	21.1
	206		baler dust	211.2
	226	11/16	barley	0
	229	12/14	alfalfa	2.4
	230		alfalfa	2.1
9	206	6/14	pasture vegetation	19.0
	220	9/16	alfalfa 1st crop	16.4
	221		alfalfa 2d crop	1.9
	222		grass hay	5.1
	225		pasture vegetation	17.6
31	203	6/14	pasture vegetation	4.6
	219	9/29	alfalfa	9.5
32	207	6/15	pasture vegetation	19.3
	210		pasture vegetation	12.0
	228	9/16	pasture vegetation	6.8
	229		alfalfa	.8
	230		alfalfa	1.0
	231		alfalfa	1.1
48	119	6/26	baler dust	76.6
57	141	6/28	alfalfa	26.6
	147	8/5	green chop[b]	1.4
	152	9/20	green chop	.6
58	145	6/28	alfalfa	23.2
	152	8/10	baler dust	10.4
	153		alfalfa	2.4
	159	10/1	alfalfa	.8
59	145	6/29	pasture vegetation	9.2
	152	8/10	pasture vegetation	3.2
	157	9/20	pasture vegetation	1.5
60	150	5/14	alfalfa	0
	154		pasture vegetation	0
	159	6/29	pasture vegetation	16.1
	162		pasture vegetation	10.8
	165		pasture vegetation	13.8
	174	8/5	baler dust	46.9
	185	9/20	pasture vegetation	5.4
	186		pasture vegetation	1.2
	190	10/1	alfalfa	1.6
68	118	6/29	pasture vegetation	8.6
	119		alfalfa	14.1
	120		baler dust	43.1
	131	10/1	alfalfa	1.1
	133	11/3	silage	0
70	200	7/5	alfalfa	14.9
	213	9/15	baler dust	50.6
	216	10/25	alfalfa	1.5
	217		alfalfa	1.6
71	162	7/7	alfalfa	17.4
	163		grass hay	.8
	168	9/15	green chop	0
	169		alfalfa 2d crop	1.8
74	209	7/7	alfalfa	25.5
	210		pasture vegetation	4.9
	225	10/25	alfalfa	11.6
75	158	7/7	alfalfa	17.4
	159		grass hay	1.1
	164	9/15	green chop	.4
	167	9/19	alfalfa	2.0
	172	10/25	silage	0
76	210	7/6	pasture vegetation	5.7
	211		alfalfa	9.1
	214	7/11	baler dust	48.8
	227	9/19	pasture vegetation	1.9
	228		alfalfa	1.1
	236	11/26	alfalfa	1.7
77	152	7/6	pasture vegetation	8.1
	153		alfalfa	13.3
	154		baler dust	98.6
	165	9/15	alfalfa	2.9
	166		alfalfa	1.0
	169		pasture vegetation	2.4
	179	11/26	silage	0
78	110	7/5	pasture vegetation	5.0
	111		alfalfa	35.6
	112		baler dust	142.9
	113		native vegetation	23.1
	125	11/26	alfalfa	1.1
	126		alfalfa	1.7
205–4	58	8/26	native vegetation	34.8

[a] Dust collected from surfaces of farm equipment used in harvesting crops—for convenience called baler dust.
[b] Alfalfa cut and fed without drying.

SECTION I. MILK AND FOOD

Milk Surveillance, February 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Foods, Pesticides and Product Safety, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and

Figure 1. Milk sampling networks in the Western Hemisphere

radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations (2σ), for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period, July–September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 14 participated in the experiment.

The iodine-131 and cesium-137 results show much improvement over previous tests. Barium-140 results also look good, which is encouraging, since this is the first time barium-140 was analyzed for this type of experiment. However, strontium-89 and strontium-90 analyses still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention

was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result due to exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0–20	20–200	200–2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.
[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1- or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]51,000
Cesium-137	Whole body			[c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

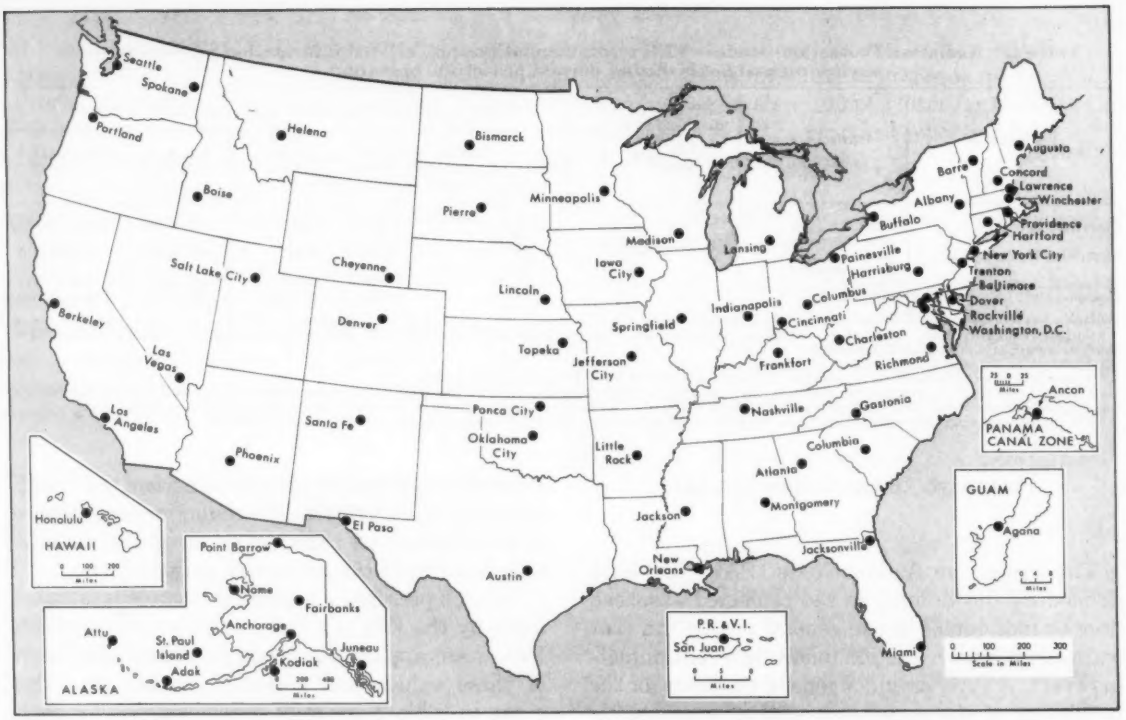

Figure 2. State and PMN milk sampling locations in the United States

maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-month averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137, for February 1970 and the 12-month period, March 1969 to February 1970. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for February

Table 3. Concentration of radionuclides in milk for February 1970 and the 12-month period, March 1969 through February 1970

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	5	6	0 (4)	0	4 (4)	9
Alaska:	Palmer[c]	P	5	6	0 (4)	0	5 (4)	6
Ariz:	Phoenix[c]	P	0	1	0 (4)	0	0 (4)	0
Ark:	Little Rock[c]	P	10	16	0 (4)	0	19 (4)	18
Calif:	Sacramento[c]	P	2	1	0 (3)	0	0 (3)	0
	San Francisco[c]	P	0	1	0 (4)	0	0 (4)	0
	Del Norte	P	14	19	0	0	19	20
	Fresno	P	2	2	0	0	2	5
	Humboldt	P	4	5	0	0	6	7
	Los Angeles	P	2	2	0	0	3	3
	Mendocino	P	3	4	0	0	6	5
	Sacramento	P	3	3	0	0	7	5
	San Diego	P	3	2	0	0	1	3
	Santa Clara	P	2	2	0	0	7	4
	Shasta	P	4	3	0	0	4	5
	Sonoma	P	1	3	0	0	5	4
Colo:	Denver[c]	P	5	5	0 (4)	0	0 (4)	1
	West	R	(d)		NS	(e)	NS	(e)
	Northeast	R	(d)		(e) (4)	(e)	(e)	(e)
	East	R	(d)		(e)	(e)	(e)	(e)
	Southeast	R	(d)		NS	(e)	NS	(e)
	South central	R	(d)		NS	(e)	NS	(e)
	Southwest	R	(d)		(e)	(e)	(e)	(e)
	Northwest	R	(d)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	6	8	0 (4)	0	8	10
	Central	P	7	7	0 (4)	0	11 (4)	11
Del:	Wilmington[c]	P	7	8	0 (4)	0	3 (4)	5
D.C:	Washington[c]	P	7	7	0 (4)	0	11 (4)	4
Fla:	Tampa[c]	P	8	6	0 (4)	0	45 (4)	54
	West	R	12	12	0	0	12	26
	North	R	17	14	0	0	28	26
	Northeast	R	6	7	0	0	24	53
	Central	R	8	8	0	0	27	49
	Tampa Bay area	R	8	8	0	0	42	54
	Southeast	R	NA	8	0	0	53	84
Ga:	Atlanta[c]	P	7	9	0 (4)	0	16 (4)	19
Hawaii:	Honolulu[c]	P	1 (3)	2	0 (4)	0	0 (4)	0
Idaho:	Idaho Falls[c]	P	6	5	0 (4)	0	4 (4)	4
Ill:	Chicago[c]	P	6	7	0 (4)	0	12 (4)	9
Ind:	Indianapolis[c]	P	8	8	0 (4)	0	8 (4)	5
	Northeast	P	9	10	0	1	15	11
	Southeast	P	10	8	0	0	20	11
	Central	P	8	9	0	0	15	12
	Southwest	P	10	10	0	0	15	13
	Northwest	P	10	10	0	0	15	17
Iowa:	Des Moines[c]	P	5	6	0 (4)	0	0 (4)	2
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita[c]	P	8	8	0 (4)	0	0 (4)	1
Ky:	Louisville[c]	P	7	8	0 (4)	0	4 (4)	5
La:	New Orleans[c]	P	12	16	0	0	12	17
Maine:	Portland[c]	P	9	11	0 (4)	0	23 (4)	23
Md:	Baltimore[c]	P	6	8	0 (4)	0	12 (4)	7
Mass:	Boston[c]	P	10	11	0 (4)	0	12 (4)	21
Mich:	Detroit[c]	P	8	8	0 (4)	0	10 (4)	9
	Grand Rapids[c]	P	8	10	0 (4)	0	7 (4)	12
	Bay City	P	6	8	0 (2)	0	15	9
	Charlevoix	P	13	11	0 (3)	0	16	18
	Detroit	P	7	6	0 (4)	0	6	6
	Grand Rapids	P	9	8	0 (2)	0	6	12
	Lansing	P	10	7	0 (2)	0	8	13
	Marquette	P	13	11	0 (2)	1	21	25
	Monroe	P	6	6	0 (2)	0	6	2
	South Haven	P	NS	7	NS	0	NS	10
Minn:	Minneapolis[c]	P	5	10	0 (4)	0	11 (4)	8
	Bemidji	P	13	17	0	0	20	26
	Mankato	P	4	8	0	0	8	11
	Rochester	P	6	8	0	0	8	9
	Duluth	P	13	16	0	0	18	21
	Worthington	P	4	7	0	0	9	7
	Minneapolis	P	9	13	0	0	12	12
	Fergus Falls	P	4	9	0	0	6	10
	Little Falls	P	6	9	0	0	12	10
Miss:	Jackson[c]	P	9	12	0 (4)	0	11 (4)	13
Mo:	Kansas City[c]	P	7	8	0 (4)	0	6 (4)	1
	St. Louis[c]	P	8	8	0 (4)	0	3 (4)	2
Mont:	Helena[c]	P	4	5	0 (4)	0	6 (3)	5
Nebr:	Omaha[c]	P	4	6	0 (3)	0	0 (4)	1
Nev:	Las Vegas[c]	P	0	1	0 (4)	0	0 (4)	0

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for February 1970 and the 12-month period, March 1969 through February 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.H:	Manchester[c]	P	10	8	0 (4)	0	16 (4)	10
N.J:	Trenton[c]	P	10	9	0 (4)	0	6 (4)	7
N.Mex:	Albuquerque[c]	P	5	3	0 (4)	0	0 (4)	0
N.Y:	Buffalo[c]	P	6	7	0 (4)	0	7 (4)	8
	New York City[c]	P	7	10	0 (4)	0	15 (4)	12
	Syracuse[c]	P	6	7	0 (3)	0	5 (3)	10
	Albany	P	NA	8	0 (3)	0	(e) (3)	(e)
	Buffalo	P	(e)	(e)	0 (4)	0	(e) (4)	(e)
	Massena	P	12	10	0	0	(e) (1)	(e)
	Newburg	P	(e)	10	0	0	(e) (1)	(e)
	New York City	P	6	10	0 (4)	0	(e) (4)	(e)
	Syracuse	P	8	7	0	0	(e) (1)	(e)
N.C:	Charlotte[c]	P	10	12	0 (4)	0	12 (4)	12
N.Dak:	Minot[c]	P	13	10	0 (4)	0	16 (4)	13
Ohio:	Cincinnati[c]	P	7	8	0 (4)	0	3 (4)	2
	Cleveland[c]	P	7	9	0 (4)	0	9 (4)	6
Okla:	Oklahoma City[c]	P	7	7	0 (4)	0	11 (4)	9
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	5	6	0 (3)	0	12 (3)	6
	Baker	P	NA	2	(e)	(e)	(e)	3
	Coos Bay	P	NA	6	(e)	(e)	(e)	10
	Eugene	P	NA	4	(e)	(e)	17	8
	Medford	P	NA	2	(e)	(e)	(e)	13
	Portland composite	P	NA	4	(e)	(e)	5 (3)	6
	Portland local	P	1	5	(e)	(e)	(e) (2)	7
	Redmond	P	NA	2	(e)	(e)	(e)	4
	Tillamook	P	NA	6	(e)	(e)	(e)	12
Pa:	Philadelphia[c]	P	7	9	0 (4)	0	4 (4)	4
	Pittsburgh[c]	P	11	11	0 (4)	0	6 (4)	8
	Dauphin	P	13	7	13	1	22	14
	Erie	P	16	10	0	6	36	23
	Philadelphia	P	13	8	0	5	28	12
	Pittsburgh	P	18	11	12	3	15	18
R.I:	Providence[c]	P	8	9	0 (4)	0	15 (4)	16
S.C:	Charleston[c]	P	8	10	0 (4)	0	15 (4)	23
S.Dak:	Rapid City[c]	P	9	8	0 (4)	0	0 (4)	4
Tenn:	Chattanooga[c]	P	9	10	0 (4)	0	12 (4)	13
	Memphis[c]	P	8	9	0 (4)	0	6 (4)	4
	Chattanooga	P	8	13	0 (4)	0	12 (4)	14
	Clinton	P	11	15	0 (2)	0	0 (2)	12
	Knoxville	P	7	10	0 (2)	0	0 (2)	4
	Nashville	P	8	8	0 (2)	0	12 (2)	5
Tex:	Austin[c]	P	0	2	0 (3)	0	0 (3)	4
	Dallas[c]	P	6	6	0 (4)	0	13 (4)	6
	Amarillo	R	NS	4	NS	0	NS	0
	Corpus Christi	R	8	5	0	0	10	2
	El Paso	R	2	2	0	0	0	0
	Fort Worth	R	NS	6	NS	0	NS	5
	Harlingen	R	NS	3	NS	0	NS	0
	Houston	R	NS	8	NS	0	NS	15
	Lubbock	R	3	4	0	0	0	0
	Midland	R	NS	2	NS	0	NS	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	NS	10	NS	0	NS	13
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	10	7	0	0	10	8
Utah:	Salt Lake City[c]	P	4	4	0 (4)	0	3 (4)	4
Vt:	Burlington[c]	P	7	8	0 (4)	0	6 (4)	13
Va:	Norfolk[c]	P	9	10	0 (4)	0	13 (4)	8
Wash:	Seattle[c]	P	5	7	0 (4)	0	0 (4)	10
	Spokane[c]	P	6	6	0 (3)	0	0 (3)	3
	Benton County	R	NS	1	NS	0	NS	7
	Franklin County	R	0	2	0	0	11	2
	Sandpoint, Idaho	R	6	11	0	0	0	26
	Skagit County	R	6	7	0	0	0	13
W.Va:	Charleston[c]	P	6	9	0 (3)	0	5 (3)	6
Wisc:	Milwaukee[c]	P	6	7	0 (4)	0	10 (4)	10
Wyo:	Laramie[c]	P	5	5	0 (4)	0	8 (4)	4
CANADA:								
Alberta:	Calgary	P	8	8	(d)		17	16
	Edmonton	P	6	7	(d)		19	14
British Columbia:	Vancouver	P	8	10	(d)		22	31
Manitoba:	Winnipeg	P	8	8	(d)		16	24

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for February 1970 and the 12 month period, March 1969 through February 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
New Brunswick:	Fredericton	P	12	13	[d]		25	18
Newfoundland:	St. Johns	P	14	17	[d]		21	33
Nova Scotia:	Halifax	P	10	10	[d]		24	20
Ontario:	Ft. William	P	10	15	[d]		19	29
	Ottawa	P	6	8	[d]		12	13
	Sault Ste. Marie	P	13	14	[d]		30	29
	Toronto	P	6	5	[d]		11	10
	Windsor	P	4	5	[d]		8	11
Quebec:	Montreal	P	6	8	[d]		15	17
	Quebec	P	8	11	[d]		25	25
Saskatchewan:	Regina	P	8	7	[d]		11	12
	Saskatoon	P	4	7	[d]		10	11
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	0	0	0	0	0	3
Chile:	Santiago	P	0	0	0	0	0	2
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Mandeville	P	3	4	0	0	60	87
Venezuela:	Caracas	P	3	2	0	0	0	0
Canal Zone:	Cristobal[e]	P	0	0	0 (4)	0	12 (4)	9
Puerto Rico:	San Juan[e]	P	4	3	0 (4)	0	9 (4)	7
PMN network average[f]			6	7	0	0	8	8

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter
Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter
Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [e].

NA, no analysis.
NS, no sample collected.

1970 were below the respective practical reporting levels. Strontium-89 was detected at Del Norte, Calif., 12 pCi/liter (State sample) and Minneapolis, Minn., 9 pCi/liter (PMN).

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for the month of February 1970, and the highest 12-month average was 19 pCi/liter (Del Norte, Calif; State sample), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 53 pCi/liter in the United States for the month of February 1970, and the highest 12-month average was 84 pCi/liter (Southeast Fla.) representing 2.3 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were generally below the practical reporting level, with the following exceptions: Pa., Dauphin (State sample) 13 pCi/liter; Pittsburgh (State sample) 12 pCi/liter.

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Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
Connecticut Diet Study	July–December 1968 and January–June 1969	February 1970
California Diet Study	October–December 1968 and January–March 1969	May 1970

1. Radionuclides in Institutional Diet Samples July–September 1969

Bureau of Radiological Health and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Office of Compliance, Food and Drug Administration (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in fifty municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions and eight auxiliary institutions distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1*, *2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen

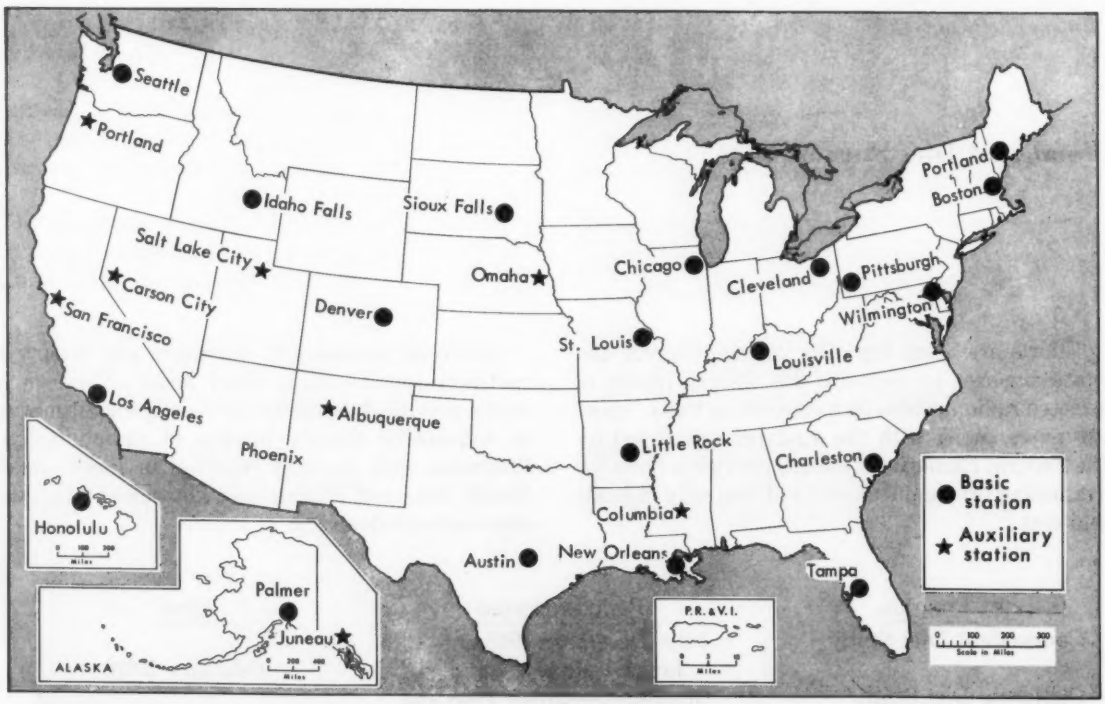

Figure 1. Institutional diet sampling locations as of June 1969

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children (9–12 years of age), July–September 1969[a]

Location of institution	Month (1969)	Total weight (kg/day)	Calcium[b]		Potassium		^{89}Sr[b]		^{90}Sr[b]		^{137}Cs	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Palmer	July[c]	1.54	0.5	0.8	1.1	1.7	0	0	5	7	0	0
	Aug[c]	1.37			1.1	1.5					0	0
	Sept	1.51			1.4	2.1					18	27
Ariz: Phoenix	July	1.81	.6	1.1	1.5	2.7	0	0	0	0	0	0
	Aug	1.64			1.7	2.7					0	0
	Sept	1.89			1.5	2.8					0	0
Ark: Little Rock[d]	Aug[c]	.98	.5	.7	1.3	1.2	NA	NA	8	10	0	0
	Sept[c]	1.59			1.5	2.4					0	0
Calif: Los Angeles	July[c]	1.50	.4	.6	1.1	1.7	0	0	3	4	0	0
	Aug[c]	1.51			1.1	1.7					0	0
	Sept[c]	1.36			1.2	1.6					0	0
Colo: Denver	NS											
Del: Wilmington[d]	Aug	2.14	.6	1.3	1.6	3.4	NA	NA	8	16	0	0
	Sept	1.81			1.7	3.1					0	0
Fla: Tampa	July[c]	1.23	.5	.7	1.4	1.8	NA	NA	6	9	24	30
	Aug	1.68			1.6	2.7					36	60
	Sept	1.20			1.5	1.8					35	42
Hawaii: Honolulu	July[c]	2.45	.4	1.1	1.4	2.8	0	0	2	6	0	0
	Aug[c]	2.40			1.4	3.4					26	62
	Sept	2.28			1.5	3.3					0	0
Idaho: Idaho Falls	July[c]	1.97	1.0	1.9	1.5	3.0	0	0	8	16	16	32
	Aug[c]	2.03			1.5	3.0					13	26
	Sept[c]	1.83			1.6	2.9					0	0
Ill: Chicago	NS											
Ky: Louisville[d]	Aug	2.89	.6	1.8	1.6	4.7	NA	NA	8	23	12	35
	Sept	2.74			1.9	5.1					0	0
La: New Orleans	July	1.96	.5	1.1	1.6	3.1	0	0	9	18	0	0
	Aug	2.03			1.6	3.3					0	0
	Sept[c]	2.16			1.7	3.6					22	48
Maine: Portland	July	1.91	.7	1.3	1.6	3.1	NA	NA	10	18	17	32
	Aug	1.63			1.6	2.6					20	33
	Sept	1.70			1.3	2.2					15	26
Mass: Boston	July	2.24	.6	1.3	1.8	4.0	6	13	9	20	21	47
	Aug	2.19			1.7	3.7					18	39
	Sept	2.19			1.8	3.9					19	42
Mo: St. Louis	July[c]	2.60	.8	2.0	1.7	4.4	NA	NA	7	17	11	29
	Aug[c]	2.22			1.6	3.6					0	0
	Sept[c]	2.42			1.7	4.1					0	0
Ohio: Cleveland	July	1.90	.7	1.2	1.6	3.0	NA	NA	7	12	11	21
	Aug	1.52			2.0	3.0					11	17
	Sept	1.78			1.7	3.0					0	0
Pa: Pittsburgh	July	2.25	.5	1.1	1.4	3.2	NA	NA	8	18	0	0
	Aug	2.32			1.2	2.8					0	0
	Sept	2.27			1.3	3.0					0	0
S.C: Charleston	July	1.18	.6	.7	1.2	1.4	NA	NA	8	11	18	21
	Aug	1.12			1.3	1.5					16	18
	Sept	2.17			1.2	2.6					0	0
S. Dak: Sioux Falls	July	1.55	.6	1.0	1.2	1.9	NA	NA	6	9	0	0
	Aug	1.49			1.3	1.9					0	0
	Sept	1.66			1.2	2.0					0	0
Tex: Austin	July[c]	1.70	.8	1.5	1.5	2.6	NA	NA	4	7	0	0
	Aug[c]	1.79			1.5	2.7					0	0
	Sept[c]	2.18			1.6	3.5					0	0
Wash: Seattle	July[c]	1.77	.5	1.0	1.5	2.6	0	0	5	9	0	0
	Aug[c]	1.90			1.7	3.3					11	21
	Sept[c]	1.79			1.4	2.6					0	0
Institutional average	July	1.85	0.6	1.2	1.5	2.8	0	0	6	12	8	15
	Aug	1.88			1.6	2.9					10	18
	Sept	1.93			1.5	2.9					7	11

[a] Iodine-131 and barium-140 were not detected at any station during this period therefore no provision was made for these nuclides in this table.
[b] Composite analysis of quarterly samples for each station.
[c] Since food samples were collected from two or more children who were not between the ages of 9 to 12, the gamma analyses for this month were not used in the institutional average. The chemistry data was included in the institutional average since this analysis was a composite of three or less individual samples.
[d] The samples for Little Rock, Ark.; Wilmington, Del.; and Louisville, Ky. were not collected for the month of July.
NA, no aralysis.
NS, no sample.

until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from July through September 1969 for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples reported in pCi/kg of diet, are corrected for

Table 2. Concentration and intake of stable elements and radionuclides in institutional total diets of individuals July–September 1969[a]

Location of institution	Month (1969)	Total weight (kg/day)	Calcium[b]		Potassium		^{89}Sr[b]		^{90}Sr[b]		^{137}Cs	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	July	0.89	0.6	0.6	2.0	1.7	11	10	14	13	0	0
	Aug	.87			1.2	1.1					16	14
	Sept	.87			1.5	1.3					13	11
Calif: Oakland	July	2.17	.7	1.5	1.8	3.9	0	0	3	7	0	0
	Aug	2.11			1.8	3.8					12	25
	Sept	1.77			1.6	2.8					0	0
Miss: Columbia	July	2.41	.9	1.9	1.5	3.6	NA	NA	5	12	18	43
	Aug	2.00			1.3	2.6					46	92
	Sept	2.21			1.4	3.2					11	24
Neb: Omaha	July	2.30	.8	1.8	1.8	4.1	NA	NA	6	14	11	25
	Aug	2.60			1.7	4.4					0	0
	Sept	2.13			1.7	3.6					0	0
Nev: Carson City	July	1.19	.9	1.2	1.2	1.5	0	0	4	5	14	17
	Aug	1.61			1.2	2.0					13	21
	Sept	1.26			1.1	1.4					0	0
N.Mex: Albuquerque	July	2.53	.8	1.8	1.6	4.0	NA	NA	2	5	0	0
	Aug	2.06			1.4	2.9					0	0
	Sept	2.23			1.6	3.6					0	0
Ore: Portland	July	1.71	.6	1.0	1.9	3.2	0	0	5	9	0	0
	Aug	1.94			2.0	3.8					12	23
	Sept	2.06			1.7	3.4					0	0
Utah: Salt Lake City	July	2.47	.5	1.2	1.2	3.0	0	0	3	7	12	30
	Aug	2.38			1.2	2.9					0	0
	Sept	2.49			1.4	3.5					0	0
Institutional average	July	1.96	0.7	1.4	1.6	3.1	2	2	5	9	7	14
	Aug	1.95			1.5	2.9					12	22
	Sept	1.88			1.5	2.9					3	4

[a] Concentrations for iodine-131 and barium-140 in pCi/kg were below detectable levels and reported as zero.
[b] Composite analysis of quarterly samples for each station.
NA, no analysis.

radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.89 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1968.

Strontium-90 dietary intake during this period averaged 12 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium-137 intakes averaged 15 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg

Data from eight auxiliary stations are included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1968	July 1969
January–March 1969 and Annual Summary 1968	October 1969
April–June 1969	January 1970

2. Strontium-90 in Tri-City Diets January–December 1969

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (HASL). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (*5*). A detailed description of the aims and methods of the HASL diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (*6*).

Starting in 1968, two changes were made in the program. The first change was the suspension of the collection and analysis of foods purchased in Chicago. Previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York City and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture in their 1965 Household Diet Survey (*7*). The changes in the composition of the diet from 1955 to 1965 are not very great, and the estimates of strontium-90 intake made using statistics from either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be affected to a greater degree. The new estimates of the consumption have therefore been used to calculate the intakes of calcium and strontium-90 for 1969 in New York City and San Francisco.

Results for January–December 1969 are presented in tables 3 through 6. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 2.

[1] Data from Fallout Program Quarterly Summary Report, HASL 214, 217, 224. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 3. Average dietary consumption and strontium-90 intake in Tri-City diet February–March 1969

Food category	Diet (kg/a)	Calcium (g/a)	New York City Febuary 1969		San Francisco March 1969	
			Strontium-90		Strontuim-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	7.5	1,500	2.4	480
Fresh fruit	59	9.4	15.8	932	3.4	201
Fresh vegetables	48	18.7	10.9	523	2.7	130
Root vegetables	10	3.8	6.8	68	6.5	65
Potatoes	38	3.8	4.7	179	3.3	125
Macaroni	3	.6	3.8	11	2.2	7
Rice	3	1.1	1.8	5	1.6	5
Fruit juices	28	2.5	3.0	84	3.6	101
Canned vegetables	22	4.4	7.7	189	2.3	51
Canned fruit	11	.6	1.5	17	.8	9
Dried beans	3	2.1	7.5	23	10.3	31
Flour	34	6.5	7.2	245	3.0	102
Bakery products	44	53.7	6.5	286	3.8	167
Whole grain products	11	10.3	13.8	64	11.0	121
Fresh fish	8	7.6	.7	6	.4	3
Shellfish	1	1.6	.9	1	.3	
Poultry	20	6.0	1.2	24	1.1	22
Meat	79	12.6	.9	71	.3	24
Eggs	15	8.7	1.6	24	1.4	21
Annual intake (pCi/a)		370		4,252		1,685
Daily intake (pCi/day)				11.6		4.6

Table 4. Average dietary consumption and strontium-90 intake in Tri-City diet May-June 1969

Food category	Diet (kg/a)	Calcium (g/a)	New York City May 1969		San Francisco June 1969	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	10.1	2,020	2.9	580
Fresh fruit	59	9.4	8.2	484	2.2	130
Fresh vegetables	48	18.7	17.1	821	2.4	115
Root vegetables	10	3.8	10.9	109	3.2	32
Potatoes	38	3.8	6.0	228	3.6	137
Macaroni	3	.6	4.5	14	2.7	8
Rice	3	1.1	1.3	4	1.5	5
Fruit juices	28	2.5	2.7	76	1.5	42
Canned vegetables	22	4.4	12.2	268	2.2	48
Canned fruit	11	.6	1.7	19	.8	9
Dried beans	3	2.1	6.6	20	12.6	38
Flour	34	6.5	5.4	184	3.0	102
Bakery products	44	53.7	5.2	229	3.6	158
Whole grain products	11	10.3	13.4	147	10.2	113
Fresh fish	8	7.6	.2	2	.2	2
Shellfish	1	1.6	.7	1	.5	1
Poultry	20	6.0	.9	18	.4	8
Meat	79	12.6	1.3	103	.3	24
Eggs	15	8.7	1.0	15	1.8	27
Annual intake (pCi/a)		370		4,762		1,579
Daily intake (pCi/day)				13.0		4.3

Table 5. Average dietary consumption and strontium-90 intake in Tri-City diet August-September 1969

Food category	Diet (kg/a)	Calcium (g/a)	New York August 1969		San Francisco September 1969	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	9.6	1,920	1.6	320
Fresh fruit	59	9.4	3.0	177	2.2	130
Fresh vegetables	48	18.7	12.6	605	2.2	106
Root vegetables	10	3.8	2.6	26	5.4	54
Potatoes	38	3.8	4.4	167	.7	27
Macaroni	3	.6	4.2	13	3.8	11
Rice	3	1.1	1.2	4	2.3	7
Fruit juices	28	2.5	5.6	157	2.0	56
Canned vegetables	22	4.4	14.2	312	1.9	42
Canned fruit	11	.6	1.6	18	1.3	14
Dried beans	3	2.1	17.9	54	13.4	40
Flour	34	6.5	7.1	241	3.0	102
Bakery products	44	53.7	6.5	286	4.9	216
Whole grain products	11	10.3	1.8	20	11.0	121
Fresh fish	8	7.6	1.9	15	.3	2
Shellfish	1	1.6	1.1	1	.4	
Poultry	20	6.0	1.7	34	1.2	24
Meat	79	12.6	1.3	103	5.8	458
Eggs	15	8.7	2.7	41	2.4	36
Annual intake (pCi/a)		370		4,194		1,766
Daily intake (pCi/day)				11.5		4.8

Table 6. Average dietary consumption and strontium-90 intake in Tri-City diet November–December 1969

Food category	Diet (kg/a)	Calcium (g/a)	New York City November 1969		San Francisco December 1969	
			Strontium 90		Strontium 90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	9.2	1,840	2.1	420
Fresh fruit	59	9.4	10.5	620	3.1	183
Fresh vegetables	48	18.7	18.1	869	4.0	192
Root vegetables	10	3.8	7.8	78	4.5	45
Potatoes	38	3.8	6.5	247	1.1	42
Macaroni	3	.6	4.0	12	3.1	9
Rice	3	1.1	1.7	5	2.5	8
Fruit juices	28	2.5	3.7	104	1.8	50
Canned vegetables	22	4.4	8.2	180	3.4	75
Canned fruit	11	.6	1.7	19	1.1	12
Dried beans	3	2.1	36.8	110	11.1	33
Flour	34	6.5	5.5	187	3.8	129
Bakery products	44	53.7	6.5	286	4.4	194
Whole grain products	11	10.3	16.2	178	6.8	75
Fresh fish	8	7.6	.3	2	.3	2
Shellfish	1	1.6	1.6	2	.6	1
Poultry	20	6.0	.7	14	1.7	34
Meat	79	12.6	.5	40	.4	32
Eggs	15	8.7	1.7	26	2.5	38
Annual intake (pCi/a)		370		4,819		1,574
Daily intake (pCi/day)				13.0		4.2

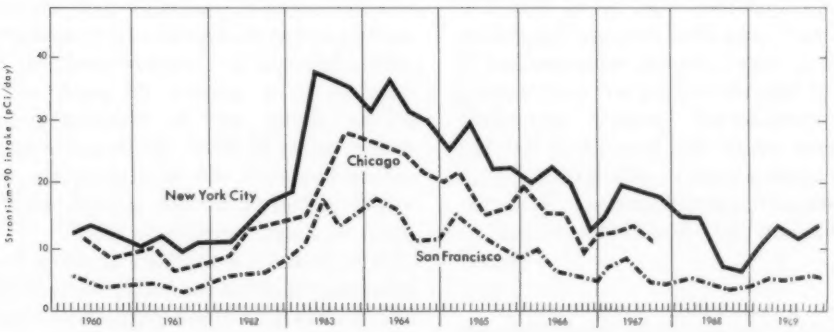

Figure 2. Daily intake of strontium-90 in Tri-City diets March 1960–December 1969

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	April 1969
July–December 1968	December 1969

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SECTION II. WATER

The Public Health Service, the Federal Water Quality Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Coast Guard Water Supplies	January 1968–July 1969	February 1970
Florida	1968	March 1970
Minnesota	January–June 1969	January 1970
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

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Radioactivity in New York Surface Water January–June 1969

Division of General Engineering and Radiological Health
State of New York Department of Health

In 1955, the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations.

Analytical procedures

A measured quantity of water, usually 500 ml, is evaporated and the residue is analyzed for its gross beta component in an end-window, gas-flow, proportional counter.

Strontium and alkaline earths are precipitated as carbonates from a 500-ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (*1–2*).

Strontium-90 is determined by yttrium-90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas-flow, proportional beta-particle counter. Strontium-89 is estimated by taking the difference between the total strontium radioactivity and that of strontium-90.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Tritium in water is determined by liquid scintillation counting of 3 ml of distilled sample in

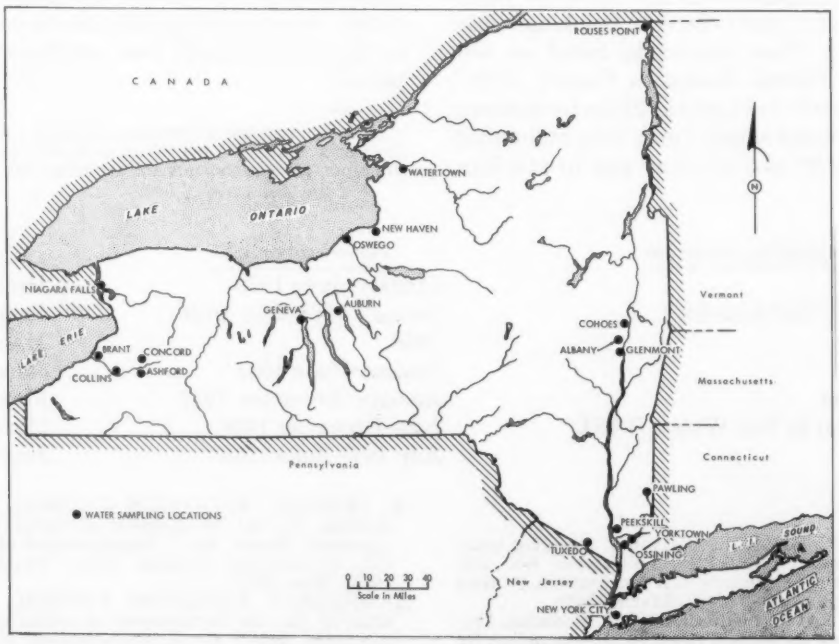

Figure 1. New York water sampling locations

17 ml of scintillator solution. The scintillator solution consists of 4 g PPO, 0.25 g dimethyl POPOP and 120 g naphthalene dissolved in 1 liter of dioxane. The sample is counted twice for a total of 100 minutes using either a Packard Tri-Carb model 3315 or a Beckman LS 200B liquid scintillation spectrometer. Minimum sensitivities at the 95-percent confidence level ± 100 percent are 1,000 pCi/liter for the Tri-Carb and 500 pCi/liter for the Beckman.

Discussion and results

With the exception of Buttermilk and Cattaraugus Creeks downstream from Nuclear Fuel Services, the results of water sampling stations in the State remain low. Water samples are obtained from 23 locations for gross beta-particle analysis (figure 1). The type of sample, number of samples, quarterly average, maximum and minimum gross beta-particle concentrations in New York surface water for January–June 1969 are given in table 1.

Table 1. Gross beta radioactivity in New York raw surface water, January–June 1969[a]

Location	Gross beta radioactivity (pCi/liter)							
	January–March 1969				April–June 1969			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	4	3	3	2	3	2	2	2
Ashford (Buttermilk Creek at Fox Valley Road)	3	7	9	4	3	4	5	3
(Buttermilk Creek at Thomas Corners)[b]	12	1,317	5,163	298	16	1,042	3,488	73
(Cattaraugus Creek)	3	6	11	3	3	5	9	3
Brant (Cattaraugus Creek)	6	116	443	28	13	75	286	16
Cohoes (Filtration Plant)[c]	13	3	4	ND	11	4	13	ND
Collins (Cattaraugus Creek)	13	80	158	24	13	110	323	16
Concord (Cattaraugus Creek)	66	147	584	32	62	124	563	ND
Geneva (Seneca Lake)	4	4	4	3	2	5	8	3
Glenmont (Hudson River)	15	3	7	ND	13	4	6	2
New Haven (Lake Ontario)	0	NA	NA	NA	3	4	4	3
New York City	8	2	4	ND	5	3	4	2
Niagara Falls (West Branch Niagara River)	5	4	5	3	3	4	4	4
Ossining (Indian Brook Reservoir)	3	5	6	4	3	2	4	ND
(Sing Sing) (Hudson River)	15	18	70	ND	13	8	23	ND
Oswego	3	4	4	3	3	3	4	3
Pawling (Pond at United Nuclear)	3	3	3	3	3	4	4	3
Peekskill (Camp Field Water Supply)	3	3	8	ND	3	5	15	ND
(Hudson River)	14	8	32	ND	13	3	6	ND
New Haven (Ontario)	0	NA	NA	NA	3	4	4	3
Tuxedo (Indian Kill)	3	4	5	3	1	7	7	7
Watertown (Black River)	3	3	4	2	3	3	4	3
Yorktown (Croton Reservoir)	3	3	5	ND	3	4	6	3

[a] Excluding tritium.
[b] This station is on the Nuclear Fuels Services reprocessing plant site.
[c] After June 16, 1969 this station will be replaced by Crescent Water Trailer.
NA, no analysis. ND, nondetectable.

Table 2. Cesium-137 and strontium-90 in New York surface waters, January–June 1969

Location	January–March 1969							April–June 1969						
		Cesium-137 (pCi/liter)			Strontium-90 (pCi/liter)				Cesium-137 (pCi/liter)			Strontium-90 (pCi/liter)		
	Number of samples	Average	Maximum	Minimum	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum	Average	Maximum	Minimum
Ashford (Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	ND	ND	ND	3	ND	ND	ND	ND	ND	ND
(Buttermilk Creek at Thomas Corners)[a]	12	319	1,161	20	489	1,386	120	15	38	155	ND	142	328	28
(Cattaraugus Creek)	3	ND	ND	ND	ND	ND	ND	3	ND	ND	ND	ND	ND	ND
Brant Cattaraugus Creek)	1	273			60			10	ND	ND	ND	10	18	ND
Collins (Cattaraugus Creek)	0	NA	NA	NA	NA	NA	NA	11	ND	100	ND	13	28	7
Concord (Springville Power Dam on Cattaraugus Creek)	12	46	161	ND	55	79	16	18	ND	ND	ND	15	47	ND
Ossining (Sing Sing) (Hudson)	15	ND	ND	ND	NA	NA	NA	13	ND	ND	ND	ND	ND	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
NA, no analysis. ND, nondetectable.

Larger samples are collected at selected locations for strontium-90 analysis. The number of samples, average, maximum, and minimum concentrations of strontium-90 and cesium-137 in New York water for January–June 1969 are given in table 2 for those stations where strontium-90 and cesium-137 was detected.

Tritium concentration values for January–June 1969 are given in table 3 for eight locations. Tritium, a very low energy beta-particle emitter, is released to the water courses during the reprocessing of nuclear fuel. The tritium concentrations in Cattaraugus and Buttermilk Creeks showed the contribution of the Nuclear Fuels Services reprocessing plant.

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	April 1969
July–December 1968	September 1969

Table 3. Tritium concentration of New York surface waters, January–June 1969

Location	Concentration (nCi/liter)							
	January–March 1969				April–June 1969			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	4	1.05	2.69	ND	3	ND	ND	ND
Ashford (Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	ND	ND
(Buttermilk Creek at Thomas Corners Road)[a]	12	132	431	5.99	16	73.2	324	1.30
Cattaraugus Creek at Bigelow Bridge	3	ND	1.80	ND	3	ND	1.12	ND
Brant (Cattaraugus Creek)	6	9.70	17.5	1.79	13	6.43	26.7	ND
Cohoes (Filtration Plant)	13	ND	2.10	ND	11	ND	1.05	ND
Collins (Cattaraugus Creek)	13	13.0	44.5	ND	13	10.2	27.6	ND
Concord (Springville Power Dam on Cattaraugus Creek)	66	18.8	73.6	ND	62	10.2	46.3	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
ND, nondetectable.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports.*

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation, *PHS*	July–September 1968	February 1970

1. Radiation Alert Network February 1970

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during February 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

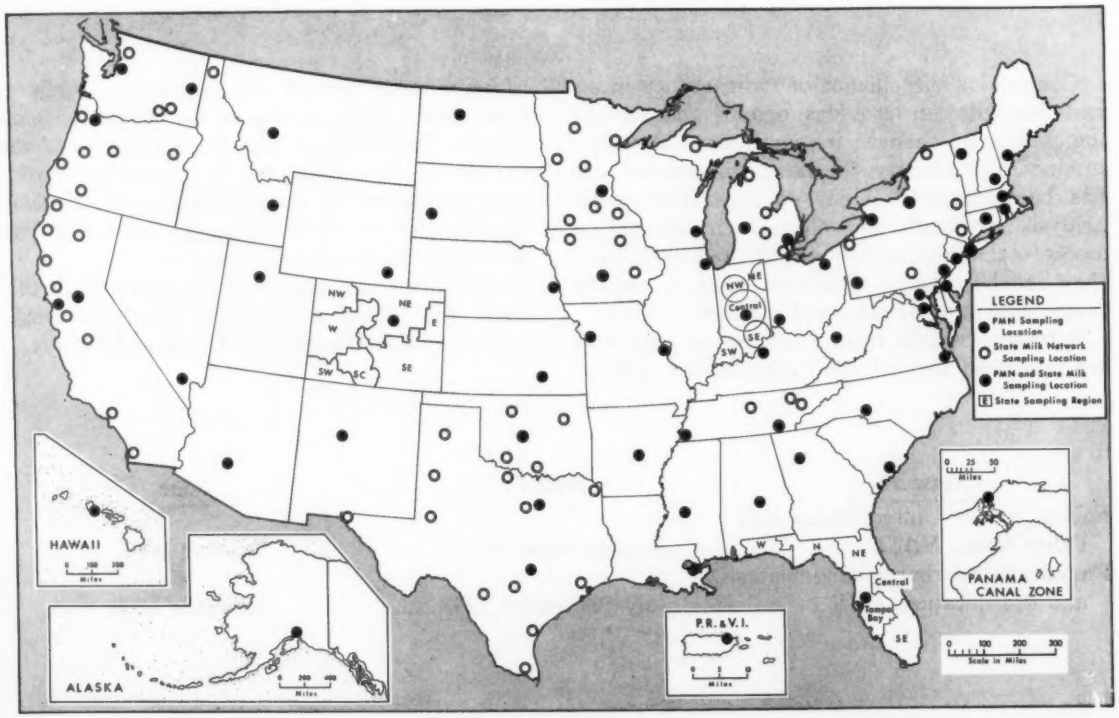

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, February 1970

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Number of samples	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	17	2	0	1	Dec 69	4	96	4	96	30
Alaska:	Adak	[b]				Dec 69	[c]				
	Anchorage	16	0	0	0	June 70	[c]				
	Attu Island	22	0	0	0	Jan 70	[c]				
	Fairbanks	12	0	0	0	Sept 69	3	7	3	7	4
	Juneau	10	8	0	2	Oct 69	6	78	6	78	0
	Kodiak	[b]				Nov 69	[c]				
	Nome	12	2	0	1	Mar 70	[c]				
	Point Barrow	[b]				Feb 70	[c]				
	St. Paul Island	[b]				Apr 70	[c]				
Ariz:	Phoenix	16	14	1	7	Oct 69	[c]				
Ark:	Little Rock	[b]				June 70	[c]				
Calif:	Berkeley	19	1	0	0	Nov 69	4	31	4	31	0
	Los Angeles	14	5	1	2	Mar 70	[c]				
C.Z:	Ancon	14	0	0	0	Nov 69	[c]				
Colo:	Denver	17	8	1	3	Nov 69	[c]				
Conn:	Hartford	18	0	0	0	Sept 69	5	65	5	65	0
Del:	Dover	17	1	0	0	May 70	[c]				
D.C:	Washington	25	1	0	0	Feb 70	[c]				
Fla:	Jacksonville	18	4	0	1	June 70	5	110	5	110	8
	Miami	18	0	0	0	Sept 69	3	48	3	48	0
Ga:	Atlanta	19	1	1	1	Apr 70	2	92	2	92	27
Guam:	Agana	[b]				May 70	[c]				
Hawaii:	Honolulu	23	2	0	1	Jan 70	[c]				
Idaho:	Boise	16	3	0	2	Jan 70	3	15	3	15	0
Ill:	Springfield	13	1	0	1	Feb 70	[c]				
Ind:	Indianapolis	[b]				Apr 70	[c]				
Iowa:	Iowa City	16	1	0	0	Nov 69	2	9	2	9	0
Kans:	Topeka	20	4	0	2	June 70	1	3	1	3	1
Ky:	Frankfort	12	1	0	0	Feb 70	[c]				
La:	New Orleans	16	1	0	0	Feb 70	5	71	[d]		
Maine:	Augusta	19	0	0	0	Mar 70	9	198	9	198	0
Md:	Baltimore	18	1	0	0	Sept 69	5	37	5	37	0
	Rockville	8	1	0	0	Jan 70	[c]				
Mass:	Lawrence	18	0	0	0	May 70	4	104	4	104	0
	Winchester	19	1	0	0	Dec 69	4	106	4	106	0
Mich:	Lansing	15	0	0	0	Jan 70	[c]				
Minn:	Minneapolis	19	1	0	0	May 70	[c]				
Miss:	Jackson	16	2	0	1	Mar 70	3	90	3	90	0
Mo:	Jefferson City	18	2	0	1	Apr 70	2	10	2	10	0
Mont:	Helena	15	2	0	1	Dec 69	2	7	2	7	3
Nebr:	Lincoln	14	5	1	3	Apr 70	1	4	1	4	3
Nev:	Las Vegas	11	4	0	2	Sept 69	[c]				
N.H:	Concord	[b]				Feb 70	[c]				
N.J:	Trenton	18	1	0	0	Mar 70	4	60	4	60	0
N. Mex:	Santa Fe	16	3	0	1	Dec 69	2	4	2	4	0
N.Y:	Albany	2	0	0	0	Apr 70	3	25	3	25	12
	Buffalo	16	0	0	0	Nov 69	[c]				
	New York City	6	1	0	0	Dec 69	[c]				
N.C:	Gastonia	16	8	0	2	Nov 69	4	38	[d]		
N. Dak:	Bismarck	18	1	0	0	Feb 70	1	2	1	2	0
Ohio:	Cincinnati	[b]				May 79	[c]				
	Columbus	4	1	0	0	Mar 70	[c]				
	Painesville	17	1	0	0	Sept 69	9	27	9	27	6
Okla:	Oklahoma City	[b]				Jan 70	[c]				
	Ponca City	20	8	0	2	Sept 69	[c]				
Ore:	Portland	18	3	0	1	Apr 70	8	58	8	58	1
Pa:	Harrisburg	15	1	0	0	Apr 70	3	52	3	52	9
P.R:	San Juan	2	2	1	1	Mar 70	[c]				
R.I.	Providence	17	1	0	0	Jan 70	1	19	1	19	1
S.C:	Columbia	19	2	0	1	Dec 69	2	47	2	47	3
S. Dak:	Pierre	13	4	1	2	Oct 69	[c]				
Tenn:	Nashville	17	1	0	0	Jan 70	7	103	7	103	8
Tex:	Austin	11	10	1	2	May 70	3	105	[d]		
	El Paso	[b]				Feb 70	[c]				
Utah:	Salt Lake City	27	8	0	2	Mar 70	4	3	4	3	0
Vt:	Barre	12	1	0	0	June 70	7	50	7	50	9
Va:	Richmond	18	1	0	0	June 70	5	58	5	58	8
Wash:	Seattle	16	1	0	0	June 70	5	36	[d]		
	Spokane	17	2	0	1	May 70	[c]				
W. Va:	Charleston	20	2	0	0	Dec 69	9	86	9	86	5
Wisc:	Madison	19	1	0	0	June 70	2	4	2	4	1
Wyo:	Cheyenne	18	7	1	2	Sept 69	1	137	1	137	1
Network summary		982	14	0	1		4	54	4	53	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

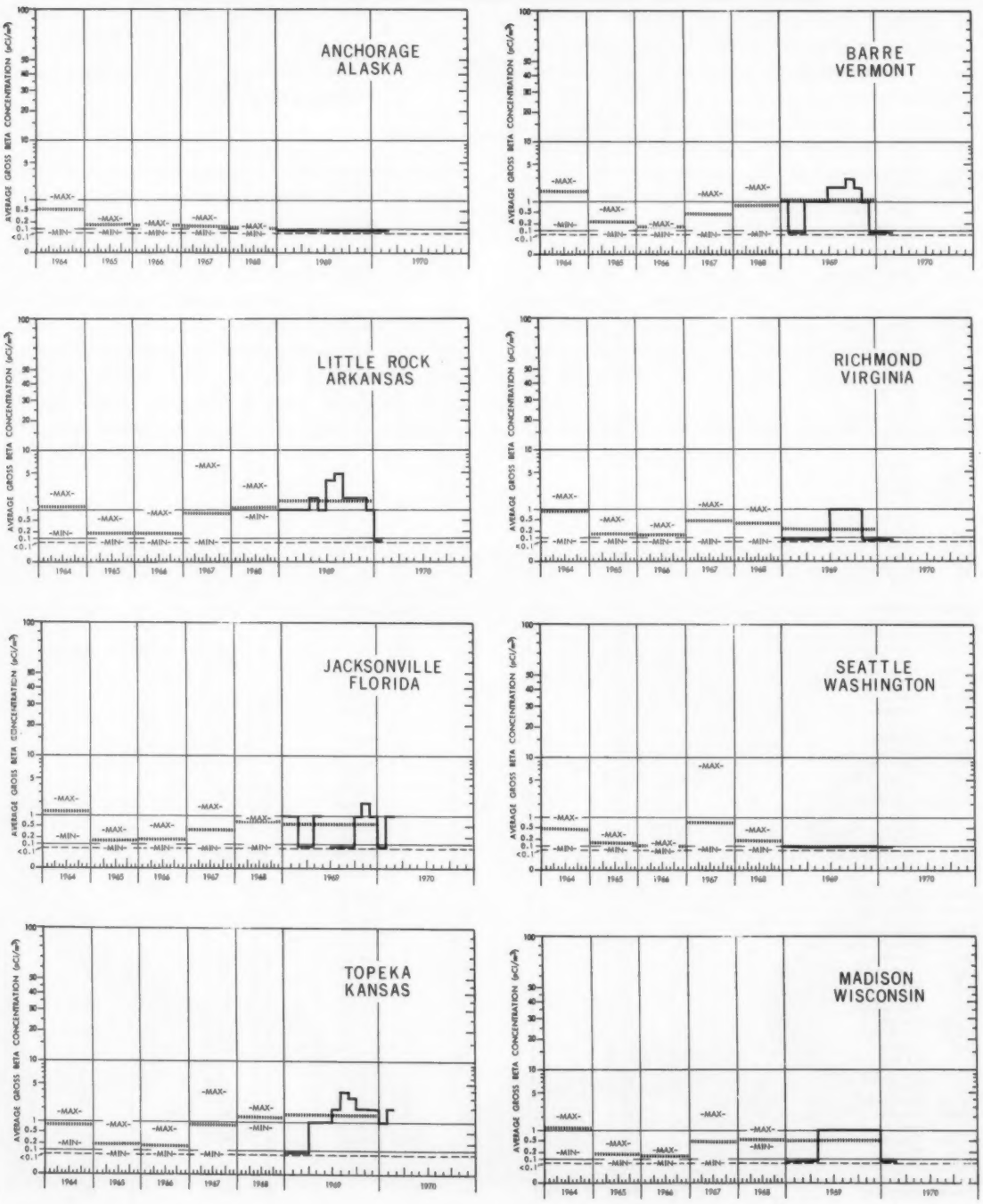

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964–February 1970

2. Canadian Air and Precipitation Monitoring Program[1], February 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for February 1970 are presented in table 2.

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipation, February 1970

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	28	0.4	0.0	0.1	58	0.5
Coral Harbour	14	.1	.0	.1	57	.3
Edmonton	28	.3	.0	.1	7	.1
Ft. Churchill	27	.1	.0	.1	21	.2
Fredericton	28	.2	.0	.1	13	1.8
Goose Bay	28	.1	.0	.1	18	.9
Halifax	28	.2	.0	.1	37	2.7
Inuvik	28	.1	.0	.1	32	.3
Montreal	28	.2	.1	.1	19	.9
Moosonee	28	.2	.1	.1	5	.1
Ottawa	24	.1	.0	.1	11	1.1
Quebec	27	.1	.0	.1	NS	NS
Regina	28	.1	.0	.1	33	.7
Resolute	28	.2	.0	.1	17	.1
St. John's Nfld.	23	.1	.0	.1	19	4.4
Saskatoon	28	.1	.0	.1	208	1.5
Sault St. Marie	28	.2	.0	.1	64	4.0
Thunder Bay	28	.2	.1	.1	37	.7
Toronto	27	.2	.0	.1	40	1.0
Vancouver	28	.3	.0	.1	49	2.7
Whitehorse	28	.2	.0	.1	42	.3
Windsor	28	.1	.0	.1	15	.4
Winnipeg	28	.1	.0	.1	14	.2
Yellowknife	27	.2	.1	.1	22	.3
Network summary	645	0.4	0.0	0.1	36	1.1

NS, no sample.

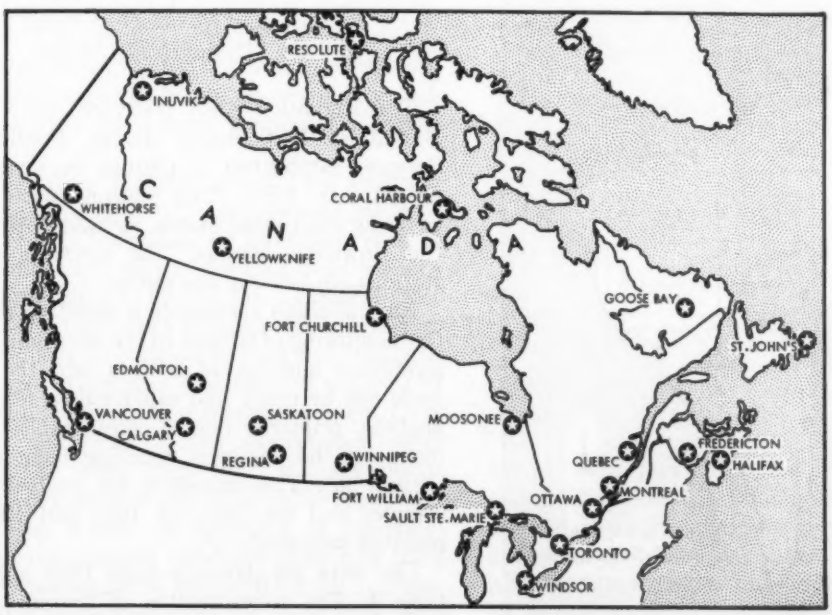

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program February 1970

Pan American Health Organization
and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The February 1970 air monitoring results from the participating countries are given in table 3.

Table 3. Summary of gross beta radioactivity in Pan American surface air, February 1970

Station		Number of samples	Gross beta radioactivity (pCi/m^3)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	NS	NS	NS	NS
Bolivia:	La Paz	1	0.01	0.01	0.01
Chile:	Santiago	11	.17	.02	.07
Colombia:	Bogota	20	.19	.01	.05
Ecuador:	Cuenca	NS	NS	NS	NS
	Guayaquil	17	.12	.02	.05
	Quito	NS	NS	NS	NS
Guyana:	Georgetown	NS	NS	NS	NS
Jamaica:	Kingston	NS	NS	NS	NS
Peru:	Lima	20	.12	.03	.07
Venezuela:	Caracas	16	.22	.01	.10
West Indies:	Trinidad	17	.12	.02	.09
Pan American summary		102	0.22	0.01	0.06

[a] The monthly average is calculated by weighting the individual sample with length of sampling period. Values less than 0.005 pCi/m^3 are used in averaging as 0.00 pCi/m^3.
NS, no sample.

Figure 4. Pan American Air Sampling Program stations

4. Tritium in Precipitation January–June 1969

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, established a tritium in precipitation program in 1967. Nine stations were selected covering the United States, including Alaska and the Hawaiian Islands. The locations of these stations are listed in the tables.

Rain analysis represents a sensitive technique for monitoring of tritium in the environment. Any significant addition of tritium into the natural cycle can be easily and rapidly detected by rain analysis, primarily due to considerable improvements in the low-level counting techniques for tritium (*6*). The procedure for analyzing these samples and the data for 1967 and 1968 were reported previously (*7*).

The data for January–June 1969 appears in table 4. The concentration of tritium at these stations for this period remains at the same level as previously reported.

Table 4. Tritium analysis of precipitation from RAN stations, January–June 1969

Locations	Concentration (nCi/liter)					
	January	February	March	April	May	June
N.C: Gastonia	NS	0.5	0.4	<0.2	<0.2	NS
Alaska: Anchorage	NS	< .2	NS	NS	NS	NS
Ala: Montgomery	<0.2	< .2	< .2	< .2	< .2	0.4
S. Dak: Pierre	NS	NS	NS	NS	NS	NS
La: New Orleans	NS	< .2	NS	< .2	NS	NS
Tex: Austin	NS	< .2	< .2	< .2	< .2	NS
Colo: Denver	NS	.5	.5	1.1	1.2	NS
Hawaii: Honolulu	NS	< .2	< .2	< .2	NS	NS
Wash: Seattle	NS	< .2	< .2	< .2	< .2	NS

NS, no sample.

5. Plutonium in Airborne Particulates and Precipitation, July–December 1968

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate and precipitation samples from selected RAN stations for plutonium. The airborne particulate and precipitation analyses were initiated in November 1965 and August 1966, respectively, and the results through September 1968 have been previously reported (*8–18*).

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from each of the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. The laboratory reduced this analysis on filters to quarterly composites as of the August 1, 1968 sample. They also discontinued analysis of precipitation for plutonium due to consistently low levels of plutonium in the environment after September 30, 1968. Eight RAN stations submit complete collections of precipitation for plutonium analysis. An 8-liter (or whatever is available) aliquot of the monthly collection of each of the 8 stations is forwarded to the NERHL for analysis. The analytical methodology for processing these samples is described in the December 1968 issue of *Radiological Health Data and Reports* (*8*).

The results for July through December 1968 are presented in tables 5 and 6. Nondetectable (ND) has been used to indicate samples containing plutonium-238 or plutonium-239 activities less than or equal to the appropriate minimum detectable activities (0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples and from 2 to 8 liters for the precipitation samples.

Table 5. Plutonium in airborne particulates July–December 1968

Location	Month (1968)	Plutonium–238 (fCi/m³)	Pluotnium–239 (fCi/m³)	Plutonium–239/plutonium–238
Alaska: Anchorage	July	0.004	0.018	4.5
	Aug–Sept	.007	.035	5.0
	Oct–Dec	.006	.029	4.8
Ariz: Phoenix	July	.004	.023	5.8
	Aug–Sept	.012	.079	6.6
	Oct–Dec	.017	.067	3.9
Colo: Denver	July	.010	.060	6.0
	Aug–Sept	NS	NS	
	Oct–Dec	NS	NS	
Hawaii: Honolulu	July	.004	.016	4.0
	Aug–Sept	.004	.015	3.8
	Oct–Dec	.005	.022	4.4
La: New Orleans	July	.004	.026	6.5
	Aug–Sept	.013	.065	5.0
	Oct–Dec	.010	.043	4.3
Md: Rockville	July	NS	NS	
	Aug–Sept	[a].009	[a].056	6.2
	Oct–Dec	NS	NS	
N.Y: Buffalo	July	.007	.039	5.6
	Aug–Sept	.012	.059	4.9
	Oct–Dec	.024	.121	5.0
N.C: Gastonia	July	.009	.042	4.7
	Aug–Sept	.015	.082	5.5
	Oct–Dec	.008	.051	6.4
S. Dak: Pierre	July	.009	.041	4.6
	Aug–Sept	.036	.135	3.8
	Oct–Dec	NS	NS	
Tex: Austin	July	.004	.022	5.5
	Aug–Sept	.008	.049	6.1
	Oct–Dec	.011	.038	3.5
Wash: Seattle	July	.004	.027	6.8
	Aug–Sept	.006	.036	6.0
	Oct–Dec	.016	.047	2.9

[a] September sample only.
NS, no sample.

Errata: The previous tables presenting data for plutonium-238 and plutonium-239 in precipitation and airborne particulates for July–September 1968 have some errors in calculations. This data appears in *Radiological Health Data and Reports* 11:92–93 (February 1970). Incorporated in this article are corrected tables for the July–September 1968 data and additional data from October–December 1968.

Table 6. Plutonium-238 and plutonium-239 in precipitation, July–September 1968

Location	Month (1968)	Precipitation depth (mm)	Concentration (pCi/liter)		Deposition (pCi/m²)	
			Plutonium-238	Plutonium-239	Plutonium-238	Plutonium-239
Alaska: Anchorage	July	19.4	0.006	0.025	0.12	0.49
	August	23.2	ND	.013		.30
	September	18.5	ND	.018		.33
Colo: Denver	July	38.4	ND	.008		.23
	August	32.6	ND	.004		.13
	September	16.1	ND	.012		.20
Hawaii: Honolulu	July	NS	NS	NS	NS	NS
	August	NS	NS	NS	NS	NS
	September	20.0	ND	ND		
La: New Orleans	July	13.7	ND	.020		.28
	August	11.3	.011	ND	.12	
	September	46.5	.118	.085	5.48	3.95
Md: Rockville	July	NS	NS	NS	NS	NS
	August	94.6	ND	.015		1.42
	September	NS	NS	NS	NS	NS
N.C: Gastonia	July	31.8	ND	.013		.41
	August	NS	NS	NS	NS	NS
	September	26.8	.006	.008	.16	.22
Tex: Austin	July	NS	NS	NS	NS	NS
	August	13.5	ND	ND		
	September	65.3	.059	.009	3.85	.59
Wash: Seattle	July	10.8	ND	.026		.29
	August	99.6	ND	.008		.79
	September	31.9	ND	.013		.41

ND, nondetectable.
NS, no sample.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Iodine-131 in Bovine Thyroids, Summary of Program Operations, 1963-1969

Bureau of Radiological Health
U.S. Public Health Service

A program to supplement existing environmental radiation surveillance activities, by collecting and analyzing bovine thyroids for iodine-131, was initiated in September 1962 on a pilot scale. The major planned objectives of the program were: (1) to establish methods for collection and analysis of bovine thyroids for the purpose of instituting an operational surveillance network, and (2) to provide a basis for developing a mathematical model relating iodine-131 concentrations in the bovine thyroid to those in milk, which might make it possible to estimate retrospectively iodine-131 levels in milk for the period 1952 to 1957, when bovine thyroids were analyzed for iodine-131 but milk was not.

The program, conducted in cooperation with the Meat Inspection Division, U.S. Department of Agriculture, was initiated with Salt Lake City, Utah, and Des Moines, Iowa, as collection points. In October 1962, Seattle, Wash., was added. In April 1963, the program was expanded to include areas where cows are on pasture all year and where many brucellosis and tuberculosis reactors come to slaughter. The added stations were Montgomery, Ala.; Atlanta, Ga.; New Orleans, La.; Jackson, Miss.; Oklahoma City, Okla.; and Dallas-Fort Worth, Tex. Modifications were subsequently made in the program to include additional collection areas, and therefore, broader coverage. Some of the collection areas were in locations which are in the PHS Pasteurized Milk Network; this was expected to be useful in obtaining comparable data for iodine-131 in milk and in bovine thyroids.

Because of the low levels of radioactivity detected during preceding periods, the program was discontinued as of March 1, 1969. Provisions have been made to resume sampling of bovine thyroids if environmental levels of iodine-131 increase significantly in the future.

Program summary

During the period from September 1962 through February 1969, the bovine thyroid collection and analysis program underwent a number of changes. The early months of the program were devoted to establishing procedures for the collection of thyroid glands and performing analyses for iodine-131. By the end of January 1963, the program became operational and the results of the findings for the period, January 20 to June 29, 1963, were published in October 1963 (*1*).

By the end of 1963, iodine-131 levels were generally down to the limit of reliability in detection, and the program was temporarily suspended through September 1964. It was resumed in October 1964 and continued through February 1969. During this period the influx of iodine-131 was detected following a number of foreign atmospheric nuclear detonations. In all, a total of 15,300 bovine thyroids were collected and analyzed for iodine-131.

The sampling and analytical procedures and discussions of error factors were published in early reports on the program (*1–3*). Data developed during the operation of the bovine thyroid program appeared in these and in subsequent issues of *Radiological Health Data and Reports* (*4–15*).

Table 1. General summary of program for analysis of bovine thyroids for iodine-131

Period covered	Number of thyroids analyzed	Origin of samples by State or region	Remarks
Jan 20–June 29, 1963	760	Ala., Ark., Colo., Ga., Idaho, Iowa, Kans., La., Miss., Mo., Okla., Tenn., Tex., Utah, Wash., Wyo.	427 from lactating cows; 333 from nonlactating cows. The highest levels were recorded during January and February, principally in the Des Moines, Iowa, and Kansas City, Mo., milksheds. Fifteen specimens had values over 100 pCi/g thyroid, including 3 having levels of 202, 240, and 378 pCi/g.
June 30, 1963–Jan 3, 1964	1,445	Ala., Ark., Colo., Fla., Ga., Idaho, Iowa, Kans., La., Miss., Mo., Mont., Nebr., Okla., S. Dak., Tenn., Tex., Utah, Wash.	875 from lactating cows; 570 from nonlactating cows. Iodine-131 concentrations during this period were generally down to the limit of reliability.
Jan 4–Sept 1964			Program temporarily suspended
Oct–Dec 1964	229	Calif., Colo., Ga., Idaho, Ill., Iowa, Kans., Ky., Minn., Miss., Mont., N.Y., S. Dak., Tenn., Tex., Utah, Vt., Wash., Wis., Wyo.	Iodine-131 activity detected following October 16, 1964, atmospheric nuclear detonation on Chinese mainland. Levels were particularly high in Colorado and New York.
Jan–June 1965	1,165	Ariz., Calif., Colo., Ga., Idaho, Iowa, Kans., Ky., Minn., Miss., N. Mex., N.Y., N. Dak., Okla., S.C., S. Dak., Tenn., Tex., Utah, Vt., Wyo.	Influx of iodine-131 from mainland China atmospheric detonation of May 14, 1965, was clearly evident in June samples.
July–Dec 1965	1,602	(1) Calif.; (2) Wash., Idaho, Utah; (3) Colo., N. Mex., western Nebr; (4) N. Dak., S. Dak., Minn., Iowa, Ill., Wis. Kans., northwest Ind.: (5) Ark., Miss., (6) Tenn., Ky., Ga., southern Ind., western N.C., (7) N.Y., Vt.	Reporting by geographic grouping of States instituted. Several samples from California (Fresno, Merced, San Joaquin, Santa Clara) showed levels of 50 to 200 pCi/g thyroid, possibly resulting from a release from a nuclear facility.
Jan–June 1966	1,746	(1) Calif.; (2) Idaho, Utah, Wash.; (3) Colo., N. Mex., northwestern Tex.; western Kans.; (4) Ill.; Iowa, Kans., Minn., S. Dak., Wis.; (5) Ark., Miss., Okla., eastern Tex.; (6) Ga., N.C., S.C., (7) N.Y., Vt.	Influx of iodine-131 following a mainland China atmospheric detonation of May 9, 1966, was evident; highest average values were observed in group 3, 4, 5, 6 States, ranging from 175 to 350/g thyroid, through mid-June.
July–Dec 1966	2,370	(1) Southwestern Ariz., Calif.; (2) northern Calif.; Idaho, Nev., Ore., Utah, Wash., Wyo.; (3) northeastern Ariz., Colo., N. Mex., western Tex.; (4) Kans., Iowa, Minn., N. Dak., S. Dak., Wis.; (5) Miss., La., Okla., eastern Tex.; (6) Ga., N.C., S.C., Tenn.; (7) N.Y., Vt.	Iodine-131 levels declined to barely detectable levels in early August. New influx following Chinese test of October 27 observed through November and December, ranging up to 280 pCi/g in late November and early December.
Jan–Mar 1967	1,021	(1) Ariz., Calif.; (2) Idaho, Oreg., Utah, Wash.; (3) Colo., N. Mex., western Tex.; (4) Iowa, Kans., S. Dak., Wis.; (5) Okla., eastern Tex.; (6) Ga., N.C., S.C., Tenn.; (7) N.Y., Vt.	Influx of iodine-131 following Chinese test of December 27, 1966, was observed through January, declining to nondetectable levels by mid-February. Peak concentrations in individual thyroids ranged from about 600 to 3,260 pCi/g, and were especially high in central California and in group 2, 3, 4, and 6 States.
April–Sept 1967	1,331	Ariz., Calif., Ga., Idaho, Iowa, Kans., La., N.C., N.Y., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Utah, Wash., Wyo.	Iodine-131 levels were generally nondetectable, although a small rise, diffused throughout the network occurred in mid to late July, with maximum levels around 20 to 25 pCi/g.
Oct–Dec 1967	647	Ariz., Calif., Ga., Idaho, Iowa, Kans., La., Minn., Miss., Nebr., Nev., N.Y., N.C., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis.	Levels were nondetectable, except for one sample (Cooke County, Texas), which contained 15 pCi/g.
Jan–Mar 1968	498	Ariz., Calif., Ga., Idaho, Iowa, Kans., La., Minn., N.Y., N.C., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis.	Moderate elevations of iodine-131 were found in 8 States during parts of January and February. The most active sample was collected in South Dakota, January 24, and contained 83 pCi/g.
Apr–June 1968	502	Ariz., Calif., Ga., Idaho, Iowa, Kans., La., Minn., Miss., Nebr., N.Y., N.C., Okla., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis.	Levels were generally undetectable; one sample (Walla Walla, Wash.) showed a level of 7 pCi/g.
July–Sept 1968	846	Ariz., Ark., Calif., Colo., Ga., Idaho, Iowa, Kans., La., Minn., Miss., Mo., Nebr., N. Mex., N.Y., N.C., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis., Wyo.	Moderate elevations were found in 11 States; the most active was collected in Garfield County, Colo., on July 30, and contained 44 pCi/g.
Oct–Dec 1968	696	Ariz., Calif., Colo., Ga., Idaho, Iowa, La., Minn., Miss., Nebr., N. Mex., N.Y., Okla., Oreg., S.C., S. Dak., Tenn., Tex., Vt., Wash., Wis., Wyo.	Levels were for the most part low or nondetectable. Two samples (Maricopa, Ariz., and Mesa, Colo.) showed levels of 31 pCi/g on Oct. 4.
Jan–Feb 1969	445	Ariz., Calif., Colo., Ga., Idaho, La., Miss., N. Mex., N.Y., Okla., S.C., S. Dak., Tenn., Tex., Wash., Wis., Wyo.	Minor elevations were found in 10 States. The most active samples were in Delta County, Colo., and Washington County, Idaho, on January 3. The levels were 23 and 36 pCi/g, respectively.

Review of findings

A general summary of the findings of the program is presented in table 1. Because of changes in the geographic alignment of the sampling locations during the course of the program and in emphasis with respect to some parameters investigated, no attempt will be made to summarize the data. The individual reports should be consulted for the actual values obtained and for discussions

of factors that might assist in placing the data into perspective. A number of conclusions, some of them confirmatory of studies reported by other investigators, may be drawn from the results of the determinations of iodine-131 in bovine thyroids.

1. The collection and analysis of bovine thyroids is an extremely sensitive method for the detection of intrusions of iodine-131 into the environment. Based on an earlier calculation (*16*) that milk levels (in pCi/liter) are, on the average, about 8 percent of the thyroid levels (in pCi/g) for iodine-131, then the lower limit of reliability for thyroid determinations would be equivalent to about 0.6 pCi/liter of milk. The data resulting from the bovine thyroid program were too scattered and variable to confirm this ratio; nevertheless, comparisons made in milkshed areas where cows were grazing before slaughter showed substantially higher (averaging something like an order of magnitude) iodine-131 values in thyroids than in milk following a foreign atmospheric nuclear test (*3*). Moreover, the increases in air radioactivity levels at the same locations were either slight or barely detectable, although they occurred sooner than the peak levels in the bovine thyroids.

2. Analyses of bovine thyroids for iodine-131 do not provide as quick a response to the intrusion of fresh fission products into the environment as the determination of radioactivity in air. It cannot, therefore, serve as an alerting approach; however, it is specific for iodine-131 and for that reason is a highly useful supplementary environmental assessment mechanism.

3. The study provided information that may be applied to studies involving considerations of metabolic and meteorologic pathways whereby intrusions of iodine-131 affect man. Among other things, it was determined that the effective half-life of iodine-131 in bovine thyroids ranged from 3 to 6 days (*3*). This closely parallels the data reported by the Federal Radiation Council for milk after deposition of this radionuclide on pasture (*17*). It may also be of interest that, in most of the locations for which the appropriate data were reported, the iodine-131 levels were higher in nonlactating cows than in lactating cows. The development of a model to relate iodine-131 concentrations in bovine thyroids to those in milk has not been undertaken to date; however, some rough correlations have appeared. These may be useful in estimating retrospectively the iodine-131 concentrations in milk in areas where bovine thyroid estimates were made prior to the initiation of milk-monitoring programs.

4. Guidelines were established which will facilitate a resumption of analyses for iodine-131 in bovine thyroids should such an action be indicated. The sensitivity and specificity of this procedure favor it as an adjunct to other environmental surveillance activities in identifying a fresh fission product intrusion. In at least one instance during the operation of the bovine thyroid program, iodine-131 was detected in bovine thyroids at a sampling location after a foreign nuclear test, while milk samples taken from the same pasture area failed to reveal evidence of the radionuclide (*3*).

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Strontium-90 in Human Bone, July-September 1969[1]

Bureau of Radiological Health
U.S. Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

[1] Period during which death or surgical procedure occurred.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

The analytical results for strontium-90 in individual bones from persons dying during the third quarter (July–September) of 1969 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, July–September 1969

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Northeast:						
New York	V	4	M	44.3± 6.7	28.2	1.57
New Jersey	V,R	5	M	41.9± 6.0	16.3	2.57
New York	V	9	M	64.8± 8.1	40.9	1.58
Vermont	V	10	M	68.9± 6.8	42.2	1.63
New York	V	12	F	73.1± 8.6	43.2	1.69
	V	12	F	168.0±14.0	69.3	2.42
	V	13	M	35.2± 5.8	24.5	1.43
Pennsylvania	V	14	M	94.4± 8.5	41.6	2.26
Massachusetts	V	18	M	120.0±11.0	48.9	2.45
New York	V	19	M	97.3± 9.7	64.6	1.50
	V	20	M	72.2± 8.3	57.6	1.25
	V	21	F	100.0± 9.1	56.4	1.77
Southeast:						
North Carolina	V	1	F	244.0±18.0	40.3	6.05
South Carolina	V	1	M	127.0±11.0	25.4	5.00
North Carolina	V	5	M	97.4± 8.0	32.1	3.03
Maryland	V	6	M	76.5±11.0	33.5	2.28
	V	9	F	99.7±10.0	34.6	2.88
	V	10	M	91.0±11.0	37.8	2.40
	V	16	M	145.0±14.0	61.6	2.35
	V	17	M	78.5±11.0	53.3	1.47
	V	17	M	107.0±12.0	49.3	2.17
	V	17	M	92.1±12.0	45.0	2.04
South Carolina	V	17	M	173.0±12.0	54.1	3.19
Maryland	V	18	M	81.5±11.0	51.2	1.59
	V	18	M	136.0±14.0	66.0	2.06
North Carolina	V	18	M	130.0±12.0	38.0	3.42
Maryland	V	18	M	161.0±13.0	59.8	2.69
Georgia	V	19	M	96.8± 9.5	63.2	1.53
South Carolina	V	19	M	85.5± 9.7	42.4	2.01
Maryland	V	19	M	136.0±12.0	64.2	2.11
	V	20	M	304.0±20.0	76.2	3.98
	V	20	M	154.0±17.0	73.7	2.08
	V	20	M	93.2±10.0	61.0	1.52
	IS	21	M	154.0±14.0	45.7	3.36
	V	21	M	109.0±11.0	49.6	2.19
	V	23	M	103.0±11.0	49.5	2.08
Georgia	V	24	F	80.2±10.0	49.2	1.63
Maryland	V	25	M	69.6± 9.5	52.3	1.33
	V	25	M	118.0±11.0	52.7	2.23
Central:						
Wisconsin	V	1	F	65.3±10.0	36.1	1.80
Minnesota	V	4	F	106.0±10.0	30.9	3.43
Wisconsin	V	5	F	73.8± 7.8	42.5	1.73
Minnesota	V	7	M	111.0± 8.8	34.7	3.19
Wisconsin	V	7	F	134.0±11.0	47.6	2.81
Minnesota	V	8	M	49.1± 6.6	29.3	1.67
Wisconsin	V	8	M	71.9± 9.7	42.7	1.68
Minnesota	V	10	M	81.6±10.0	43.9	1.85
Ohio	V	10	M	91.8±10.0	34.5	2.66
	V	10	M	74.7±10.0	39.8	1.87
	V	12	F	73.9± 6.6	41.2	1.79
	V	14	M	118.0±13.0	50.7	2.32
	V	14	M	138.0±11.0	43.7	3.15
	V	15	M	90.3± 8.7	49.5	1.82
	V	15	M	144.0±12.0	44.9	3.20
	V	16	M	120.0±13.0	54.5	2.20
	V	17	F	189.0±12.0	68.6	2.75
Michigan	V	17	M	121.0±11.0	71.7	1.68
Ohio	V	18	M	105.0±11.0	64.2	1.63
	V	18	M	112.0±11.0	56.0	2.00
	V	19	M	193.0±16.0	61.0	3.16
	V	19	F	140.0±12.0	63.8	2.19
	V	19	F	101.0±10.0	50.9	1.98
	V	20	M	103.0±10.0	55.1	1.86
	V	20	M	116.0±10.0	61.3	1.89
Iowa	V	20	M	123.0±13.0	53.2	2.31
Ohio	V	21	M	113.0±12.0	55.7	2.02
	V	21	F	119.0±11.0	53.2	2.23
	V	21	M	126.0±13.0	61.5	2.04
Michigan	V	22	F	66.8± 7.5	47.5	1.40
Ohio	V	22	F	72.5±10.0	54.7	1.32
	V	22	M	73.5± 9.9	49.6	1.48
Minnesota	V	23	F	95.8± 9.0	55.1	1.73
Ohio	V	23	M	84.4± 8.2	62.3	1.35
Michigan	V	24	F	132.0±14.0	70.0	1.88
	V	24	M	111.0±12.0	68.8	1.61
Ohio	V	24	M	89.7±12.0	56.7	1.58
Northwest:						
Oregon	V	3	F	49.7± 7.2	32.2	1.54
	V	6	M	60.3± 9.1	32.7	1.84
	V	8	M	55.4± 6.6	26.0	2.13
	V	16	M	85.7±10.0	54.9	1.56

See footnotes at end of table.

Table 1. Strontium-90 in human bone, July–September 1969—Continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Oregon	V	17	M	104.0±11.0	48.8	2.13
	V	17	F	93.8± 8.4	54.9	1.70
	V	17	M	58.4± 6.3	34.8	1.67
	V	17	F	75.6±10.0	52.3	1.44
Washington	R	17	M	91.8± 8.7	40.9	2.24
Oregon	V	18	F	82.3± 8.2	45.5	1.80
	V	19	M	38.8± 5.8	25.0	1.55
	V	19	M	61.2± 6.1	43.3	1.41
	V	21	M	84.1±10.0	54.8	1.53
	V	22	F	80.1±11.0	58.9	1.35
	V	22	M	69.0± 9.6	44.8	1.54
	V	24	M	49.8± 5.6	49.9	.99
	V	25	M	59.8± 9.7	58.2	1.02
Southwest:						
California	V	21	F	49.4± 7.4	47.3	1.04

[a] Type of bone, V, vertebrae; R, rib; IS, ischium.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–6*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1968	December 1969
January–March 1969	March 1970
April–June 1969	May 1970

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(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

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(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64–1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

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(*5*) HALLISEY, R. M. and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Mound Laboratory and the National Reactor Testing Station.

[1] Title 10, Code of Federal Regulations, Part 20 "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Mound Laboratory[2] January–June 1969

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specified for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and tritium (hydrogen-3) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air within a radius of 20 miles from the laboratory during the collection period. Since the sampling zone is dependent on the wind direction, it is possible that air samples from all zones will not be collected during the reporting period.

Airborne polonium and plutonium particulates are collected with a high-volume air sampler. The filter papers are then processed such that counting results are specific for polonium and plutonium. One fourth of each filter paper is processed by spontaneous deposition to isolate polonium. The remaining three fourths of each filter paper is processed chemically to remove polonium. The remaining alpha radioactivity is interpreted as plutonium; however, some of this alpha radioactivity is probably due to naturally occurring alpha-particle emitters.

Airborne tritium is monitored by bubbling air through a liquid scintillation counting solution with p-dioxane as the organic solvent. The counting solution is counted directly in a liquid spectrometer.

The results of the airborne monitoring program are presented in tables 1, 2, and 3. The average concentrations of plutonium, polonium, and tritium, in the environment are below the AEC radiation protection standards.

[2] Summarized from "Environmental Monitoring Report: January–June 1969" (MLM–1615).

Table 1. Atmospheric monitoring of polonium-210 Mound Laboratory environs, January–June 1969

Range (miles)	Number of samples	Concentration (fCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	24	39.5	16.2	0.08
0–3 (downwind)	24	35.8	9.9	.05
3–5 (downwind)	23	38.9	14.5	.07
5–10 (downwind)	24	33.6	14.4	.07
10–15 (downwind)	25	30.3	15.8	.08
15–20 (downwind)	24	35.7	12.4	.06

[a] Lowest detectable level (LDL) for polonium-210 in air is 8.0 fCi/m^3 for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5.3 fCi/m^3 for samples collected 0–3 miles downwind and 15–20 miles downwind. Allvalues which were not detectable were set equal to these values when average values were calculated.
[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m^3.

Table 2. Atmospheric monitoring of plutonium-238 Mound Laboratory environs, January–June 1969

Range (miles)	Number of samples	Concentration (fCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	24	10.8	5.1	0.51
0–3 (downwind)	24	61.1	7.3	.73
3–5 (downwind)	24	183.3	12.0	1.20
5–10 (downwind)	23	12.6	4.7	.47
10–15 (downwind)	24	15.3	5.0	.50
15–20 (downwind)	24	15.6	3.6	.36

[a] Lowest detectable level (LDL) for plutonium-238 in air is 1.3 fCi/m^3 for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.9 fCi/m^3 for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.
[b] The applicable AEC radiation protection standard for plutonium-238 in air is 70 fCi/m^3.

Table 3. Atmospheric monitoring of tritium, Mound Laboratory environs, January–June 1969

Range (miles)	Number of samples	Concentration (nCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	23	4.91	1.33	0.66
0–3 (downwind)	23	12.19	1.61	.80
3–5 (downwind)	22	1.68	1.06	.53
5–10 (downwind)	23	1.45	1.04	.52
10–15 (downwind)	23	1.09	1.00	.50
15–20 (downwind)	22	3.58	1.14	.57

[a] Lowest detectable limit for tritium in air is 1.00 nCi/m^3. All values which were not detectable were set equal to this value when average values were calculated.
[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m^3.

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed separately to reduce the concentra-

tions of these radionuclides to a level at which they may be discharged to the environment. Treated polonium liquid waste is discharged to the Great Miami River via a closed sewer line which also carries the treated plant sewage. The treated plutonium waste is discharged to a drainage ditch which runs through the plant site and eventually reaches the river.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of tritium. In addition, tritium is recovered from various AEC tritium-contaminated wastes. Liquid waste generated by these operations is treated (diluted with water when necessary) and is discharged to the drainage ditch which runs through the site and eventually reaches the river. Some tritium-contaminated liquid wastes are discharged to the same closed sewer line as polonium.

Water samples are collected weekly from the Great Miami River, the drainage ditch, and two ponds northeast of Mound Laboratory (figure 1). The average concentrations of plutonium and tritium in water discharged to the environment were well below the AEC radiation protection standards. Average concentrations of tritium, polonium-210, and plutonium-238 are given in table 4 for January–June 1969.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	May 1969
July–December 1968	December 1969

Table 4. Offsite water monitoring for radioactivity, Mound Laboratory environs, January–June 1969

Radionuclide and sampling locations[a]	Number of samples	Concentration	
		Maximum	Average[b]
Polonium-210:[c] (pCi/liter)			
1 (Drainage ditch)	24	36.04	4.99
2 (Upstream from laboratory)	24	2.70	1.84
3 (Laboratory effluent)	24	2,117.12	267.94
4 (250-yards downstream)	24	29.73	4.39
5 (Chautauqua Road Bridge)	24	371.17	17.23
6 (Chautauqua Dam)	24	6.31	1.99
7 (Franklin, Ohio)	24	<1.80	1.80
8 (Pond, opposite V.A. hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	23	<1.80	1.80
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory)	23	<1.80	1.80
Plutonium-238:[c] (pCi/liter)			
1 (Drainage ditch)	24	472.71	65.01
2 (Upstream from laboratory)	24	6.98	4.65
3 (Laboratory effluent)	23	519.14	68.60
4 (250-yards downstream)	25	8.93	5.38
5 (Chautauqua Road Bridge)	25	48.65	6.86
6 (Chautauqua Dam)	25	6.19	4.76
7 (Franklin, Ohio)	24	7.17	4.88
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	23	6.34	4.63
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory)	23	10.32	5.14
Tritium[c] (hydrogen-3): (μCi/liter)			
1 (Drainage ditch)	24	22.97	2.47
2 (Upstream from Laboratory)	24	.88	.13
3 (Laboratory effluent)	24	15.97	1.64
4 (250-yards downstream)	24	.72	.09
5 (Chautauqua Road Bridge)	24	3.67	.22
6 (Chautaugua Dam)	24	.38	.08
7 (Franklin, Ohio)	24	1.74	.17
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	22	.22	.08
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory)	23	.77	.10

[a] See figure 1 for number of sampling locations.
[b] The applicable AEC radiation protection standards for uncontolled area are as follows:
Polonium-210 in water: 700 pCi/liter.
Plutonium-238 in water: 5 nCi/liter.
Tritium in water: 3 μCi/liter.
[c] Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.
Minimum detectable level for plutonium-238 in water is 4.5 pCi/liter.
Minimum detectable level for tritium in water is 50 nCi/liter.
All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

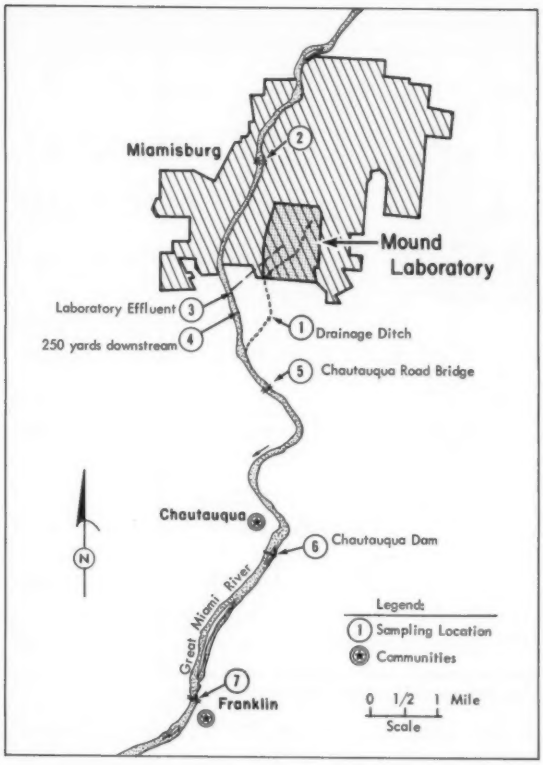

Figure 1. Water sampling locations, Mound Laboratory

2. National Reactor Testing Station[2] July–December 1968

Health Services Laboratory
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the second half of 1968 did not contribute significantly to environmental radiation or radioactivity concentration levels. These levels remained well below the Atomic Energy Commission standards as set forth in AEC Manual Chapter 0524. These standards are based on FRC recommendations. In choosing applicable standards for drinking water, credit has been taken for the fact that no significant quantities of radium-226 or radium-228 have been released to the environs by NRTS operations. The concentrations of radioactivity reported include contributions from all sources, such as fallout and natural radioactivity. Samples of air, water and milk are collected routinely at stations shown in figure 2. The results of the analyses performed on the air, water, and milk samples are shown in table 5 for July–December 1968 and table 6 for the year 1968.

Water monitoring

Liquid wastes containing small quantities of radioactivity from various operating facilities at NRTS are released to the ground-water table through disposal wells and seepage ponds located near each facility. Before disposal, the liquid wastes are monitored at NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly from those populated areas nearest the site boundaries. Samples from these locations, as shown on the accompanying map plus the onsite samples, provide adequate information on the underground water leaving NRTS. A total of 22 onsite production wells are sampled twice monthly. The offsite underground water is sampled at 12 locations. Offsite surface water samples are collected from the Snake River at Idaho Falls and Bliss, Idaho. The offsite water sampling frequency is once every 6 months.

Air monitoring

The filters from air samplers, operated continuously, are collected and analyzed weekly. These filters are analyzed for gross alpha, gross beta, and iodine-131 radioactivity. A total of nine sampling locations are used for reporting the concentration of air radioactivity. The eight onsite sampling locations and Idaho Falls are shown in figure 2. The offsite concentrations indicate the level of radioactivity from natural and nuclear fallout material. During 1968, the average concentration of gross beta radioactivity onsite

[2] Summarized from "Environmental Monitoring Report No. 23, July–December and Annual Summary—1968," U.S. Atomic Energy Commission, Idaho Operations Office, Health Services Laboratory, National Reactor Testing Station.

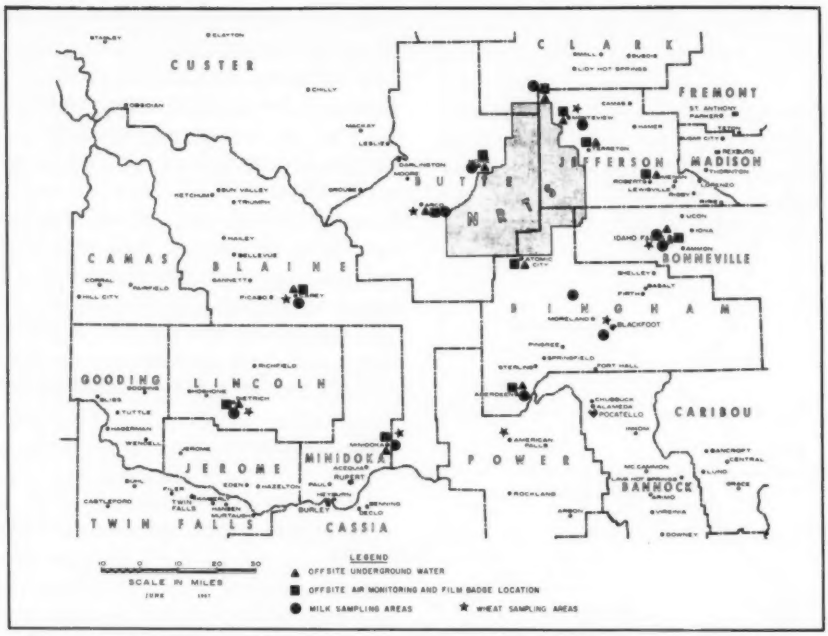

Figure 2. Environmental monitoring stations, National Reactor Testing Stations

Table 5. Environmental monitoring data for the National Reactor Testing Station, July–December 1968

Type of sample and units	Number of samples	Type of radioactivity	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC Standard
Onsite production well water (pCi/liter except tritium)	251	Alpha	3	10	<3	3,000
		Beta	5	30	<6	3,000
		Tritium (nCi/liter)	2	340	11.8	100,000
Offsite underground water (pCi/liter except tritium)	12	Alpha	3	5	<3	100
		Beta	5	7	<5	100
		Tritium (nCi/liter)	2	<2	<2	3,000
Surface water (pCi/liter except tritium)	2	Alpha	3	<3	<3	100
		Beta	5	<5	<5	100
		Tritium (nCi/liter)	2	<2	<2	3,000
Onsite air (pCi/m³)	208	Alpha	0.001	0.002	0.002	1
	216	Beta	.003	13.6	.63	300
	186	Iodine-131	.01	.82	.04	9,000
Offsite air (pCi/m³)	26	Alpha	.001	.005	.003	0.04
	26	Beta	.003	11.0	.59	10
	26	Iodine-131	.01	.07	< .02	100
Offsite milk (pCi/liter)	89	Iodine-131	20	<20	<20	100
	12	Strontium-90	1	4	<3	200
Offsite area monitoring badges (mR)	12	Gamma	5	45	<31	85
Offsite, wheat	6	Strontium-90	2	10	<5	none

was 25 percent higher than the average background concentration measured in Idaho Falls. This difference is attributed to operations at the site. On the other hand, the average yearly concentration of gross alpha radioactivity in Idaho Falls is 34 percent higher than that at the site. Investigations are underway to find the source of this higher gross alpha concentration in Idaho Falls. All monitoring results are listed in tables 5 and 6.

Offsite milk monitoring

Offsite milk samples are collected from 12 locations routinely and analyzed for strontium-90

Table 6. Environmental monitoring data for the National Reactor Testing Station, January–December 1968

Type of sample and units	Number of samples	Type of radioactivity	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC Standard
Onsite production well water (pCi/liter, except tritium)	469	Alpha	3	9.0	<3.1	3,000
	469	Beta	5	36	<6.0	3,000
	487	Tritium (nCi/liter)	2	340	10.9	100,000
Offsite underground water (pCi/liter, except tritium)	24	Alpha	3	5.3	<3.2	100
	24	Beta	5	6.8	<5.2	100
	24	Tritium (nCi/liter)	2	<2	<2	3,000
Surface water (pCi/liter, except tritium)	4	Alpha	3	4.5	<3.5	100
	4	Beta	5	<5	<5.0	100
	4	Tritium (nCi/liter)	2	<2	<2	3,000
Onsite air (pCi/m³)	406	Alpha	.001	.007	.0022	1
	422	Beta	.003	13.6	.64	300
	388	Iodine-131	.01	5.16	< .08	9,000
Offsite air (pCi/m³)	52	Alpha	.001	.005	.0030	0.04
	53	Beta	.003	11.0	.51	10
	46	Iodine-131	.01	.16	< .02	100
Offsite milk (pCi/liter)	179	Iodine-131	20	20	<20	100
	24	Strontium-90	1	10	<4	200
Offsite area monitoring badges (mR)	25	Gamma	10	145	<40	170

and iodine-131. A composite grade A sample is collected weekly from an Idaho Falls dairy. This composite sample contains milk from areas north and south of Idaho Falls. Milk samples are collected monthly from all sampling locations. The sampling locations are shown in figure 2 and the results are given in tables 5 and 6. No iodine-131 was detected at any time during the year. The strontium-90 concentrations are attributed to worldwide fallout.

Gamma radiation levels

Semiannual measurements (table 5) of external gamma radiation levels were made with thermoluminescent dosimeters (TLD) at 12 offsite locations during July–December 1968.

Natural background radiation levels at TLD locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 50–150 mR/a. This indicates that NRTS operations have added no significant radiation to surrounding areas.

Wheat monitoring

Wheat samples were collected from six different locations during the 1968 fall harvest. The sampling locations are shown in figure 2, and the analysis results in tables 5 and 6. The wheat hull has been found to contain approximately 90 percent of the strontium-90. This means that only 10 percent of the measured radioactivity remains with the wheat after processing. As in milk, the concentration of strontium-90 in wheat is the result of worldwide fallout.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Calendar year 1967	October 1968
January–June 1968	August 1969

Reported Nuclear Detonations, May 1970

(Includes seismic signals from foreign test areas)

During May 1970, nine United States nuclear tests at the Nevada Test Site were announced by the U. S. Atomic Energy Commission. Two low yield tests (less than 20 kilotons TNT equivalent) were conducted underground on May 1 and one test on May 5, 1970.

An underground nuclear test with a yield of less than 20 kilotons was conducted on May 12, 1970, at the Atomic Energy Commission's Nevada Test Site as part of a Department of Defense program related to methods of detecting, identifying, and locating underground nuclear detonations.

A nuclear test in the low-intermediate yield range (20 to 200 kilotons TNT equivalent) was conducted May 15, 1970.

Two nuclear tests were conducted underground on May 21, 1970. One was in the low yield range of less than 20 kilotons and the other test in the low-intermediate yield range between 20 to 200 kilotons.

Two underground nuclear tests with different purposes were conducted May 26, 1970, by the Atomic Energy Commission at its Nevada Test Site. One was weapons related and in the low yield range of less than 20 kilotons. A small amount of radioactivity seeped to the atmosphere following this test of May 26, 1970. No radioactivity has been detected beyond the immediate vicinity of the test.

The other nuclear test was part of the Commission's Plowshare Program to develop nuclear explosives especially designed for peaceful uses. This test is one of a series developed for the possible use in excavation experiments. Following this second test on May 26, 1970, a slight release of radioactivity to the atmosphere took place. There was no release of radioactivity as a result of the detonation itself and the radioactivity was measurable only in the immediate vicinity of the sampling effort, well within the boundaries of the test site. Neither release resulted in any health hazard to personnel at the site.

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